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THE UNIVERSITY OF ALBERTA

PALYNOLOGY OF THE MANNVILLE GROUP (LOWER CRETACEOUS),
CENTRAL ALBERTA

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES IN
PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF DOCTOR OF PHILOSOPHY

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DEPARTMENT OF GEOLOGY

by

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UNIVERSITY OF ALBERTA
FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Palynology of the Mannville Group (Lower Cretaceous), Central Alberta", submitted by Chaitanya Singh, B.Sc., M.Sc., in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

ABSTRACT

120 species belonging to 53 genera of microspores* and pollen grains, 16 species representing 8 genera of marine microplankton, 23 species belonging to 10 genera of megaspores and two specimens of seed are figured and described from the Mannville Group in central Alberta. 16 species of microspores and pollen, 2 species of marine microplankton and 7 species of megaspores are proposed as new. Three wells, Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.), Anglo-Home-C. and E. Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.) and Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.) provided the illustrated microflora.

The Lower Mannville palynological assemblages have been correlated with the established Barremian-Aptian palynological zones of the northwestern Europe. A few stratigraphically significant species of spores, making their entrance during Barremian-Aptian times in Russia and Australia, also occur in the Lower Mannville strata. The palynological assemblages of the Upper Mannville have been integrated with the known Middle Albian megafaunal and microfaunal sequences in these beds. The Upper Mannville megaspore assemblage has counterparts in the Australian Albian. The microplanktonic elements of the Upper Mannville are common with those known from the Lower Cretaceous of northwestern Europe and Australia. Most of the schizaeaceous spores described from Russia also occur in the Mannville beds and have considerable stratigraphic significance.

* sensu miospore

The pollen studies show that there is a complete gradation in evolution throughout the Mannville Group. There are no indications of any major floral breaks within the group.

The Mannville Group in central Alberta lacks angiosperms and contains only ferns, pteridosperms, cycads and conifers. The ephedralean pollen were introduced into the Mannville microflora from an arid habitat and were not derived from the regional flora. The floral elements of the Mannville Group suggest a warm-temperate to subtropical humid climate.

The marine microplankton were introduced into the Upper Mannville strata during the Middle Albian boreal flooding. The palaeoecological study indicates a continental origin for the Lower Mannville followed by a brackish and marine environment in the Upper Mannville with a return to fresh-water conditions close to the top.

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CHAPTER ONE - INTRODUCTION

Just (1951) described Mesozoic palynology as an almost virgin field. Most of the earlier investigations in palynology were restricted to the coal-bearing strata of the Palaeozoic for the correlation of the coal seams, and to the Pleistocene deposits for glacial studies. During the recent years significant contributions have been made to the Mesozoic palynology in north-western Europe, Russia, Australia and North America. Palynology has become established as a valuable research discipline for stratigraphic correlation and palaeoecological and evolutionary studies of floras. It has been applied extensively to strata from Silurian to Pleistocene in age. Several oil companies have collected a substantial amount of information about the spore and pollen complexes of the Mesozoic in this and other countries and have applied them successfully to the stratigraphic problems. It is anticipated that the marine microplankton shall be widely used for zoning the marine beds and shall enable the palynologists to extend their activity to the older strata of Proterozoic to Silurian age.

Scope of the Project

Fossil pollen and spores occur in both the fresh-water and brackish to marine facies of the subsurface Lower Cretaceous Mannville Group of central Alberta. The brackish to marine middle portion of the Mannville has yielded a datable microfauna of foraminifera belonging to the Middle Albian Substage,

but the age of the fresh-water pelecypods and ostracodes, found in the continental Lower Mannville, has been in long dispute.

The principal objectives of this palynological study were to ascertain the age of the continental Lower Mannville and to determine the microfloral assemblage of the Mannville Group in central Alberta as completely as possible. It was also aimed to establish the microfloral sequence and the entrance levels of all the stratigraphically significant species. An attempt to determine the broad plant groups which constituted the Mannville flora was also to be made for palaeoecological and palaeoclimatic interpretations.

In order to achieve these objectives samples representing 10 feet or less of core material were collected from the Mannville strata in the subsurface of central Alberta. Because of the danger of contamination from the overlying beds, drilling samples were not used in this project. These samples were processed and closely examined for microspores, pollen, marine microplankton and megaspores. The major portion of this study has been devoted to the systematic descriptions of 72 genera and 161 species of microspores, pollen, marine microplankton and megaspores obtained from the Mannville Group. Detailed illustrations of the Mannville microflora are given on Plates 1 to 29. The distribution and the relative abundance of each species in each sample have been recorded on Tables I, II and III (in pocket). A quantitative estimate of the relative abundance and stratigraphic distribution of the megaspores within the Mannville Group is given on Table IV.

As the microfloral studies within the Western Canadian Basin are at present only in the preliminary stages the Lower Mannville palynological assemblages were correlated with the established Barremian-Aptian palynological zones of the northwestern Europe. Some stratigraphically significant species described from Russia and Australia were also utilized for determining the age of the continental Lower Mannville strata. The palynological assemblages of the Upper Mannville have been integrated with the known Middle Albian megafaunal and microfaunal sequences in these beds. Some microspore and pollen species described from the Albian Stage of Russia and megaspore species described from the Australian Albian have their counterparts in the Upper Mannville strata. The megaspores were found to be of considerable stratigraphic significance. The marine microplankton were mainly utilized as environmental indicators. The palaeoecological studies have supported the interpretations concerning the sedimentational history of the Mannville Group, based on the lithological studies made by various workers.

Location of the Material Used

The cored sections of the Mannville Group were sampled in 3 wells, one of which is situated within the Edmonton Channel, another one slightly to the east of it and the third one is on the western flank of the Wainwright Ridge in central Alberta (see Figure 2). A total of 156 samples were processed and examined for microflora. The depths represented by each sample in each well

are given on Tables I, II and III (in pocket). The location of the 3 wells, the total footage cored in the Mannville Group and the total number of samples taken from each well are given below:

Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.), cored interval in the Mannville Group is 375 feet from which 30 samples were taken.

Anglo-Home-C. and E. Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.), cored interval in the Mannville Group is 854 feet from which 92 samples were taken.

Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.), cored interval in the Mannville Group is 362 feet from which 34 samples were taken.

Review of Previous Work

The first publication on Lower Cretaceous palynology in North America was on the material described by Miner (1935b) from the coals of Kootenai Formation. Rouse (1959) published a paper on the Kootenay coal-measures strata of British Columbia. Groot and Penny (1960) described plant microfossils from the Potomac Group (Lower Cretaceous to lowermost Upper Cretaceous) of Maryland and Delaware in the United States. Pocock (1962) has published information concerning the microfloral assemblage and the age of the strata at the Jurassic-Cretaceous boundary in the Western Canadian Plains.

He has examined the sediments from the Vanguard Formation (Upper Jurassic) to the Wabiskaw Member (Middle Albian) for microflora. The samples for this preliminary palynological study were collected from 18 localities lying in northern Alberta, the Peace River area, central Alberta, the Foothills area, southern Alberta and southern Saskatchewan. Although it was meant to be only a reconnaissance study and all the species present in the Mannville microflora were not described, this contribution is indispensable as a basis for future detailed studies at this horizon. Pocock (in press) has also described pollen and spores of the Chlamydospermidae and Schizaeaceae from the Upper Mannville equivalents from the Saskatoon area of Saskatchewan. Steeves has made detailed studies on the Lower Cretaceous palynology of Saskatchewan and has a paper on this subject in press.

Extensive work has been published on the Lower Cretaceous palynology in Europe. Thiergart (1949) attempted to construct a palynological column from the Lower Keuper (Triassic) to Paleocene (Tertiary) of Germany and Austria. Dijkstra (1951) and Hughes (1955) have published papers on the Wealden megaspores. Delcourt and Sprumont (1955, 1957) and Couper (1958) have described the Mesozoic, especially the Wealden spores and pollen in Europe. Deflandre (1936, 1937), Gocht (1957, 1959) and Eisenack (1958) have made important contributions to the study of Lower Cretaceous marine microplankton in Europe. In Russia, Bolkhovitina (1953, 1956 and 1959a) and Maljavkina (1956, 1958) have carried out major studies on the Mesozoic,

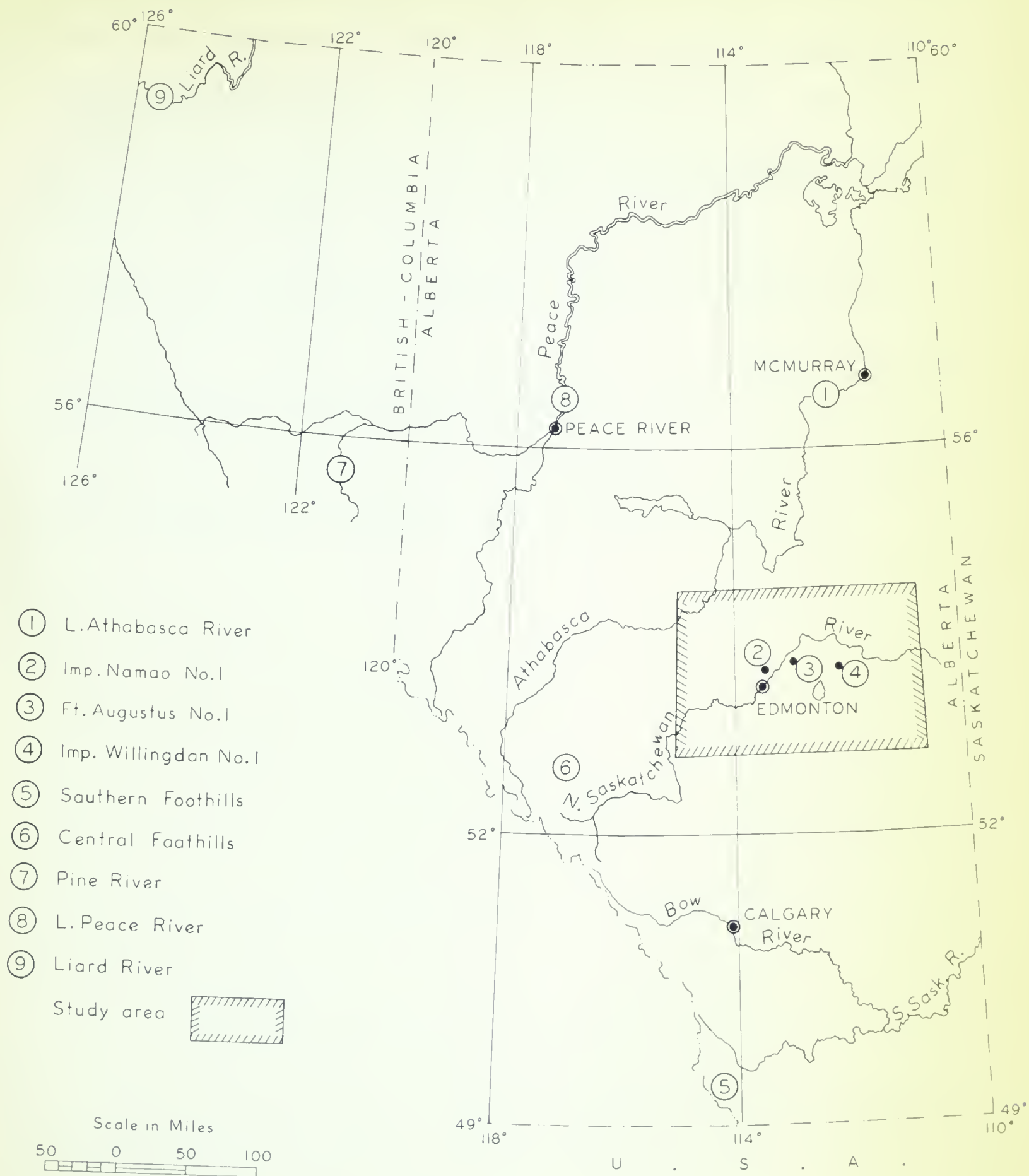


FIGURE 1. INDEX MAP

especially Lower Cretaceous palynology. Samojlovitch and Mchedlishvili (1961) have compiled the information available on the pollen and spores of western Siberia from Jurassic to Paleocene age. Couper (1953, 1960) has published papers on the Mesozoic and Cenozoic spores and pollen from New Zealand. Balme (1957) has described and illustrated the Mesozoic spores and pollen grains from Western Australia. Cookson and Dettmann (1958a, 1958b and 1959) have published many papers on the Mesozoic and especially Lower Cretaceous microspores and megaspores in Australia. Cookson and Eisenack (1958, 1960 and 1962) have made significant contributions to the study of the Mesozoic microplankton from Australia and New Guinea.

CHAPTER TWO - STRATIGRAPHY

Pre-Cretaceous Topography in Central Alberta

The Mannville Group in central Alberta was deposited over a gently undulating series of broad valleys and rounded ridges sculptured mainly in the Palaeozoic carbonates. It overlaps the eroded surface of progressively older rocks towards the east and northeast, ranging from the rocks of Jurassic and Mississippian age west of the Fifth Meridian to the rocks of older Upper Devonian age (Woodbend Group) slightly west of the Fourth Meridian (see Figure 2). The pre-Mannville topography consisted of a series of sub-parallel ridges and valleys trending slightly west of north. Edmonton Channel drained the country southeast of Edmonton and flowed northward into the Arctic Sea. Wainwright Ridge which is about 60 miles east of Edmonton Channel also has a slightly west of north trend. About 40 miles northeast of the Wainwright Ridge and trending essentially parallel to it is another valley, which drained towards the north, known as the St. Paul Channel.

The thickness of the Lower Cretaceous deposits varies considerably in different localities. In general, the thickest deposits occur in the western part near the Foothills, especially near the Pine River area in northeastern British Columbia, while all formations are considerably thinner near the Canadian Shield.

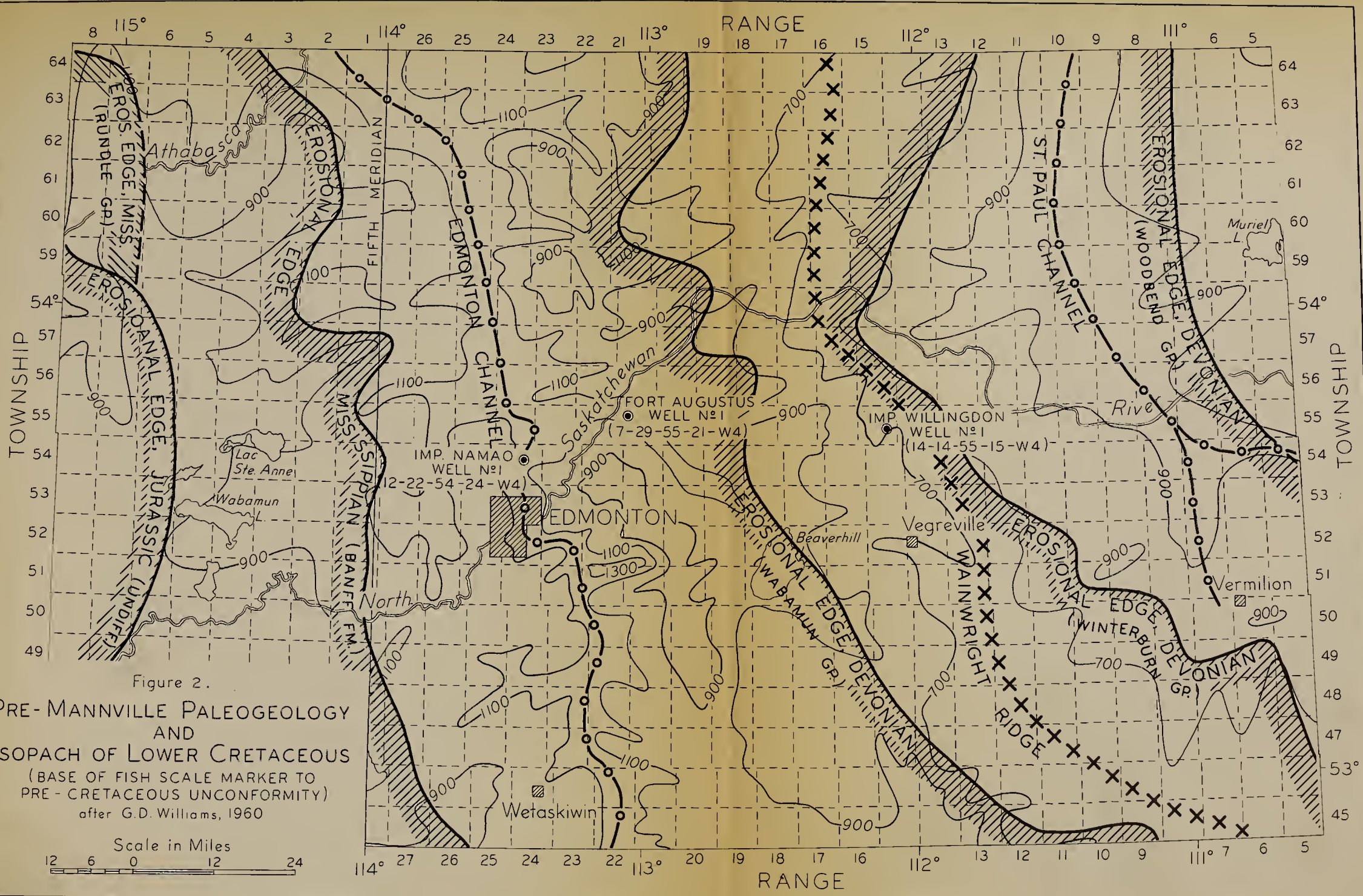


Figure 2.
 PRE-MANNVILLE PALEO GEOLOGY
 AND
 ISOPACH OF LOWER CRETACEOUS
 (BASE OF FISH SCALE MARKER TO
 PRE-CRETACEOUS UNCONFORMITY)
 after G.D. Williams, 1960

Depositional Environment and Palaeogeography

The Mannville strata in central Alberta, consisting of a sequence of rock stratigraphic units representing distinct environments of deposition, were laid down on the pre-Cretaceous surface. The earliest beds, deposited as a result of prolonged weathering and a slow accumulation of erosional detritus and original regolith in low areas, are known as the Deville Member. Overlying this detrital zone are beds of quartz sandstone with lenses of silty shale called the Ellerslie Member, which represents a widely spread fluvial deposit, probably as a result of a slow decrease in drainage gradient, burying most of the pre-Cretaceous topography except a few high ridges e.g. Wainwright Ridge. Lying above these fluvial deposits are beds of calcareous shale and coquinas of gastropod, pelecypod, ostracode and fish remains known as the "Calcareous" Member, which represents a lacustrine or lagoonal phase of deposition changing from fresh-water to slightly brackish towards the top. At the end of this continental phase of deposition, which has been designated as the McMurray Formation, a marine transgression took place from the Arctic Sea (boreal transgression) during the Middle Albian Substage, the maximum extent of which is shown on Figure 3. In the initial stages of the boreal flooding the deposition of a glauconitic sandstone, known as the Wabiskaw Member, took place, which probably developed as shallow offshore bars in the transgressing sea. As the sea became deeper, Clearwater shale

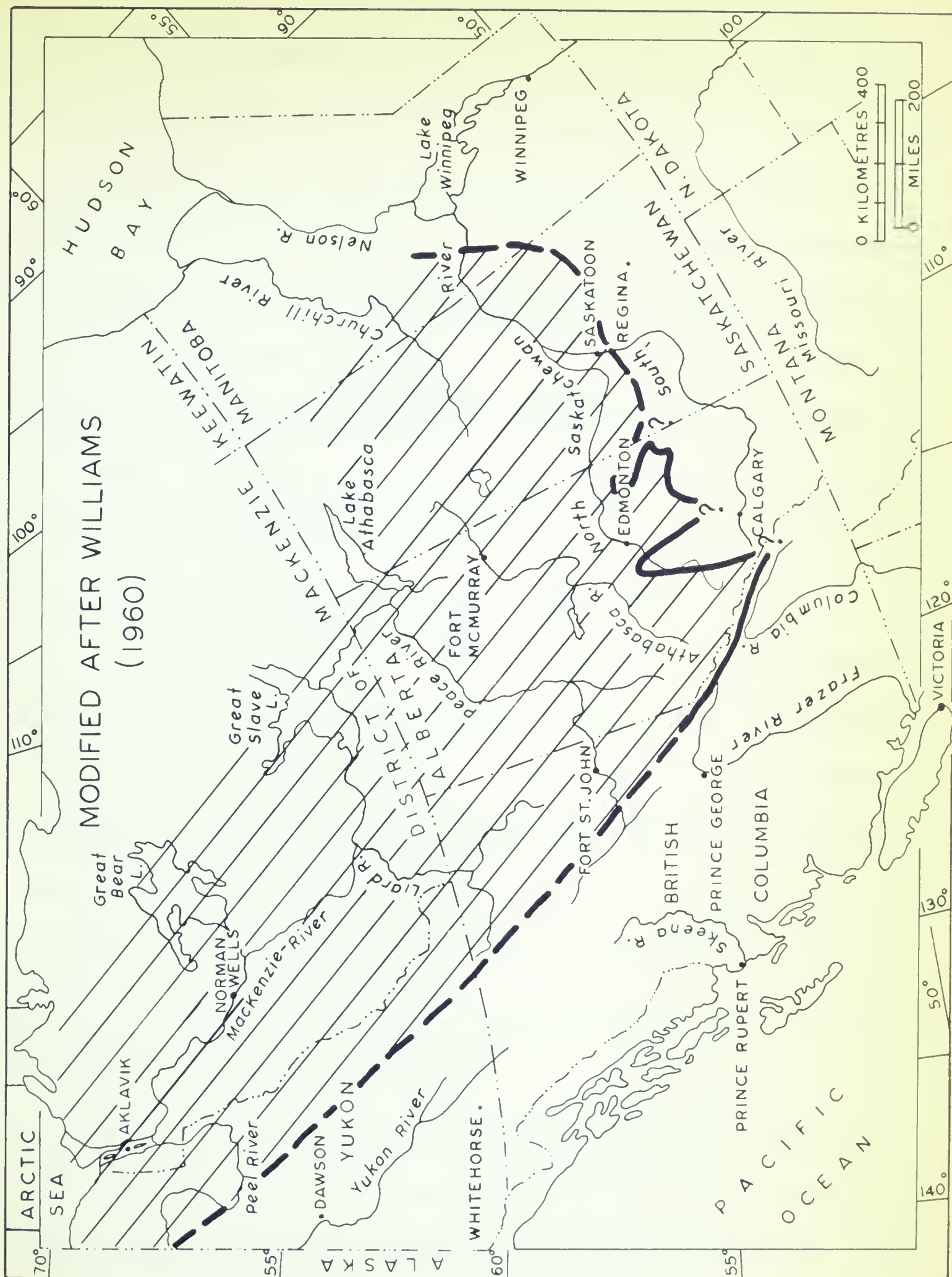


FIGURE 3. Maximum extent of Loon River-Clearwater sea.

representing the maximum flooding from the Arctic Sea was deposited. This marine shale is transitional with the overlying greywacke, siltstone, carbonaceous shale and coal known as the Grand Rapids Formation, which is believed to have been deposited in a deltaic environment. These beds represent the regressive phase of the boreal flooding, except for the topmost beds in the east-central Alberta (St. Edouard Member) which represent the transgressive phase of flooding from the Gulf of Mexico (Gulfian transgression). The Gulfian transgression took place during the Upper Albian Substage which united with the northward retreating sea from the Arctic and expanded into the widespread Upper Cretaceous Colorado sea (Stelck, 1958).

The Mannville Group by this definition includes all the Cretaceous rocks deposited before the Gulfian flooding as well as the St. Edouard Member (Badgley, 1952) in east-central Alberta. The post-Palaeozoic (locally post-Mississippian and post-Jurassic) erosional surface marks the lower limit of this group and the base of the overlying marine black shale (Joli Fou Formation) deposited during the Gulfian flooding marks the upper limit. The Mannville Group in central Alberta represents the southern marginal facies of the boreal transgression, flooding, and withdrawal.

Nauss (1945, 1947) introduced the name Mannville Formation for all the strata above the erosion surface on the Palaeozoic and below the Colorado marine shale in the subsurface of east-central Alberta in the

Vermilion area. He divided the Mannville strata into six members, which in ascending order are Dina, Cummings, Islay, Tovell, Borradaile, O'Sullivan, and described marine microfauna from the Cummings Member. Badgley (1952) raised Mannville Formation to group status and extended the Athabasca River formational names of McMurray, Clearwater and Grand Rapids to the Lower Cretaceous rocks of the subsurface in the Edmonton - Lloydminster area. The original members of Nauss' Mannville Formation were somewhat local and subsequent work (Stelck et al., 1956) has correlated the microfaunal assemblage from Cummings Member with the Clearwater shale fauna of northern Alberta. Glaister (1959) sub-divided the Mannville Group of the southern and central Plains subsurface into the Lower and Upper Mannville Formations, drawing the boundary at the top of the widespread ostracode-bearing "Calcareous" Member. This twofold division of the Mannville Group is based on a lower sequence of protoquartzite type sandstone with the calcareous ostracode-bearing member at the top and an upper sequence of feldspathic greywacke and feldspathic and chloritic arkoses which become increasingly glauconitic at the base towards the north. Williams (1960) who studied the regional aspect of the Mannville Group divided it into McMurray, Clearwater and the Grand Rapids Formations in the Edmonton-McMurray area. He further sub-divided the McMurray Formation into Deville, Ellerslie and 'Calcareous' Members (in ascending order) and distinguished the glauconitic Wabiskaw Member at the base of the Clearwater Formation.

The type section for the Mannville Group is in the cored interval at Northwest Mannville No. 1 well (Lsd. 1, Sec. 18, Tp. 50, R. 8, W. 4th Mer.) between 1833 feet and the Palaeozoic unconformity at 2308 feet.

McMurray Formation

F. H. McLearn (1917) proposed the name McMurray Formation for the bitumen-impregnated quartz sandstones along the Athabasca River. The McMurray Formation in the Edmonton area usually consists of a basal zone of erosional detritus called the Deville Member (Badgley, 1952), a middle quartz sandstone facies known as Ellerslie Member (Hunt, 1950) and an upper calcareous set of shaly beds which have been informally termed the "Calcareous" Member (Glaister, 1959) or the "Ostracode Zone" (Loranger, 1951).

The top of the McMurray Formation is marked by the basal glauconitic sandstone of the overlying Clearwater Formation, and the base is marked by the erosional surface on the underlying Palaeozoic carbonates. Contacts between the three members of the McMurray Formation are usually gradational.

The Deville, Ellerslie and "Calcareous" Members are respectively 35 feet, 248 feet and 42 feet in thickness in Imperial Namao No. 1 well; 77 feet, 212 feet and 45 feet in thickness in Anglo-Home-C. and E. Fort Augustus No. 1 well and all the three members are missing by non-deposition in Imperial Willingdon No. 1 well (see Figure 4). Fossil marine microplankton occur in the Imperial Willingdon No. 1 well down to the unconformable contact of the

Cretaceous section with the Palaeozoic carbonates indicating that the continental McMurray Formation is missing by non-deposition in this well. It appears that the Wainwright Ridge on which this well is situated remained exposed until it was inundated by the boreal flooding.

The Deville Member is described by Badgley (1952, p. 7) as consisting of "greenish grey, waxy shales; greenish grey, silty shales; greenish grey, shaly siltstones; greyish green, argillaceous, quartzose sandstones; and dark reddish brown shales and silty shales. Sideritic nodules are commonly embedded in the shales."

The type section for the Deville Member is in the cored interval at the Imperial Deville No. 1 well (Lsd. 9, Sec. 36, Tp. 51, R. 20, W. 4th Mer.) between 3555 feet and the Palaeozoic unconformity at 3605 feet.

The name Ellerslie was applied by Hunt (1950) to the "Quartz Sand Series" (Layer, 1949) of the Edmonton area. The Ellerslie Member as described by Williams (1960) consists of "very fine-to medium-grained sandstone, siltstone, and silty, micaceous, somewhat carbonaceous grey shales the sandstones typically contain 75 to 95 per cent quartz, 5 to 15 per cent rock fragments (mainly quartzites and metamorphic rocks) and 0 to 8 per cent orthoclase feldspar. Muscovite is common, especially in shaly laminae In general, the lowest beds tend to be coarser grained, somewhat conglomeratic and occasionally cross bedded; the middle portion becomes fine-grained and massive; and the upper

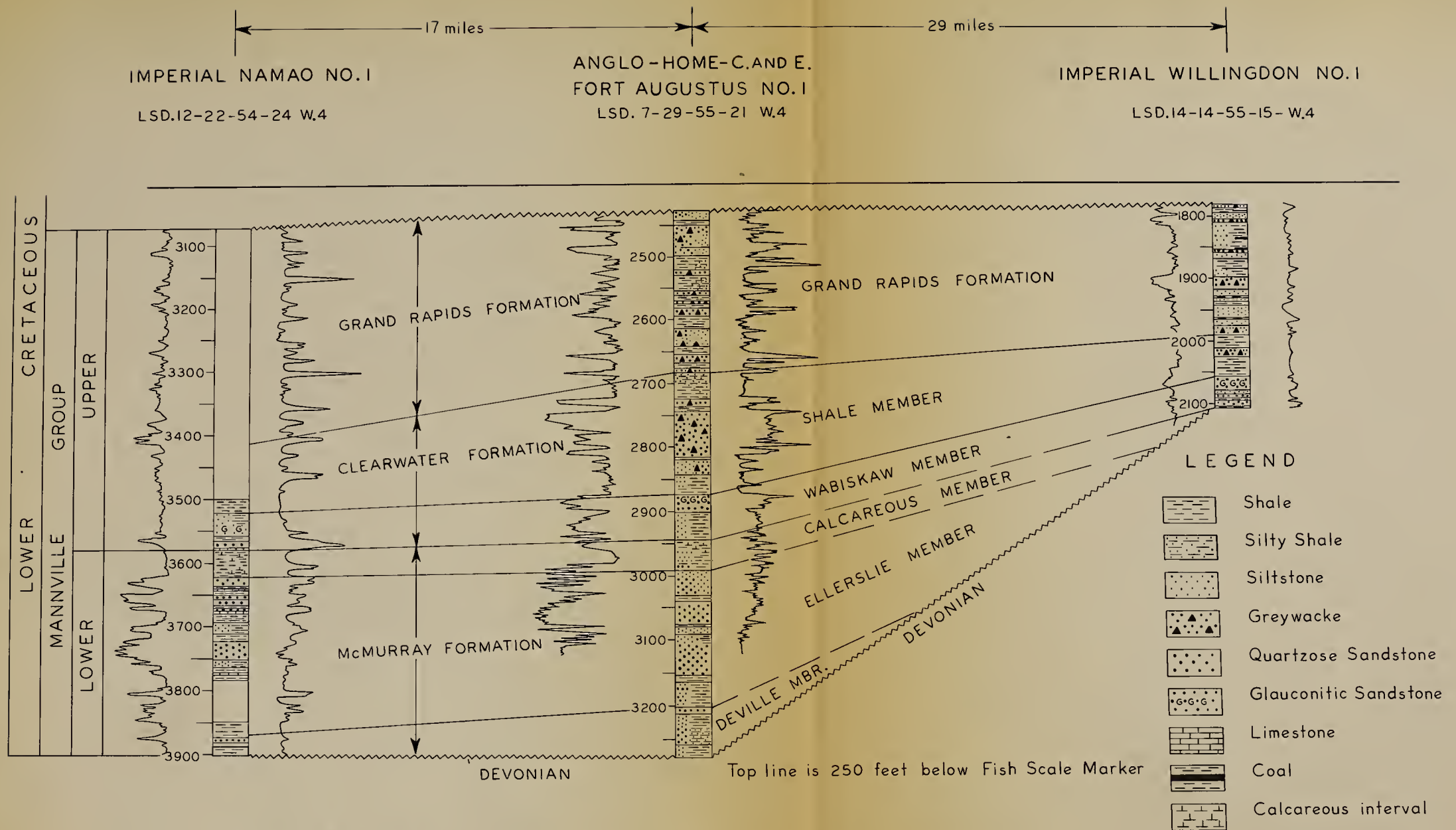


FIGURE 4. STRATIGRAPHIC CROSS SECTION OF THE MANVILLE GROUP
IN CENTRAL ALBERTA.

beds tend to be very fine-grained sandstone to siltstone, more shaly and finely bedded to laminated. The characteristics of these beds coincide fairly well with Carrigy's (1959) subdivision of the type McMurray Formation."

The type section for Ellerslie Member is in the cored interval at Tennessee W.B. McEachern No. 2 well (formerly Imperial Whitemud No. 3 well) (Lsd. 12, Sec. 14, Tp. 51, R. 25, W. 4th Mer.) between 4045 and 4200 feet in the Edmonton area.

The "Calcareous" Member (Glaister, 1959) usually referred to as "Ostracode Zone", Metacypris persulcata zone (Loranger, 1951) or Metacypris angularis zone (Badgley, 1952) is composed of dark grey, slightly brownish to black, calcareous shales, silty shales and thin calcareous sandstones. Sideritic coquinas of gastropod, pelecypod, ostracode and fish remains are common.

No type section was originally designated by Glaister (1959), though in a personal communication to Pocock (1962) he has favoured the assignment of the outcrop section on the Sheep River in southern Alberta in Sec. 35, Tp. 19, R. 5, W. 5th Mer. as type section (Crooked Hole sequence).

Clearwater Formation

The Clearwater Formation was named by McConnell (1893) on the Athabasca River at Pointe La Biche. In the Edmonton area this formation consists mainly of dark grey somewhat blocky shales, dark grey silty shales

and very fine-to medium-grained "salt and pepper" sandstones which are usually glauconitic. The base of the formation is marked by a persistent glauconitic sandstone known as the Wabiskaw Member (Badgley, 1952).

The lower contact of the Clearwater Formation is transitional with the underlying "Calcareous" Member at the top of the McMurray Formation in Imperial Namao No. 1 well and Anglo-Home-C. and E. Fort Augustus No. 1 well but rests unconformably on the Palaeozoic erosion surface in the Imperial Willingdon No. 1 well. The top of the Clearwater Formation is transitional and interfingers with the overlying sandy beds of the Grand Rapids Formation. The contact between the Shale Member and the underlying Wabiskaw Member of the Clearwater Formation is always transitional.

The Wabiskaw and the Shale Members of the Clearwater Formation are respectively 55 and 110 feet thick in Imperial Namao No. 1 well; 70 and 195 feet thick in Anglo-Home-C. and E. Fort Augustus No. 1 well and 52 and 65 feet thick in Imperial Willingdon No. 1 well.

The Wabiskaw Member in central Alberta is described by Williams (1960) as follows: "The Wabiskaw Member consists of very fine-to medium-grained "salt and pepper" sandstones containing abundant sedimentary and low rank metamorphic rock fragments (including some chert), dark grey silty shales and thin stringers of siderite. The glauconite content is variable, both laterally and vertically, at one point attaining a concentration of about 12 per cent, and

is predominantly dark green in colour. The lower beds of the member contain fewer dark grains, especially along the western flank of the Wainwright Ridge. Along the axis of the Edmonton Channel near Edmonton the Wabiskaw Member loses much of its sand content and becomes a sandy glauconitic shale in part. Throughout the area the top of the member is more distinct than the base and forms an easily recognized electric log and lithologic marker." Imperial Willingdon No. 1 well which is on the western flank of the Wainwright Ridge shows strong development of glauconite at the top but the lower beds of the member are nearly devoid of glauconite.

The type section of the Wabiskaw Member is at the Barnsdall West Wabiskaw No. 1 well (Lsd. 11, Sec. 17, Tp. 78, R. 2, W. 5th Mer.).

The Shale Member of the Clearwater Formation consists of massive medium grey shale and silty shale with a few thin ironstone bands in the upper part, thin streaks of white micaceous sand throughout and increasing glauconitic sandy shale bands toward the base.

The Shale Member of the Clearwater Formation represents the maximum flooding by the Middle Albian boreal sea and is exclusively marine in origin. The fauna of this boreal flooding is distinct and restricted. Only shallow-water arenaceous foraminifera are known from the Imperial Willingdon No. 1 well on the western flank of the Wainwright Ridge, but calcareous neritic forms are known from wells within the Edmonton Channel.

Grand Rapids Formation

McConnell (1893) described the Grand Rapids Formation from its outcrops on the Athabasca River. In the Edmonton area this formation consists mainly of medium-grained, poorly sorted, iron stained, feldspathic, "salt and pepper" sandstones, medium grey silty carbonaceous shale and coal. The lower part of the formation interfingers with the underlying Clearwater shale and is transitional with that formation. The top of the Grand Rapids Formation is placed at the base of the overlying Joli Fou marine shale, and therefore the basal sands (St. Edouard Member) introducing the Joli Fou flooding (gulfian transgression) are included within the Grand Rapids Formation. Inasmuch as the basal beds to the Joli Fou sea were derived from the Grand Rapids Formation, no diagnostic lithologic criteria are available to distinguish them. Palynological evidence of this break is not clear as reworking also recycles the fossil pollen and spores. In east-central Alberta it was distinguished on the basis of electrolog expression and named St. Edouard Member by Badgley (1952). These beds sometimes show more porosity and better sorting as a result of reworking. Although St. Edouard Member has been included within the Mannville Group for the convenience of mapping, this places a disconformity within the top portion of the Grand Rapids Formation.

The Grand Rapids Formation is 340 feet thick in the Imperial Namao No. 1 well; 255 feet thick in the Anglo-Home-C. and E. Fort Augustus No. 1 well and 209 feet thick in the Imperial Willingdon No. 1 well.

In the wells studied, there is strong palynological evidence that the greater portion of the Grand Rapids Formation is brackish and only the uppermost beds (see Tables II and III in the pocket) are deemed to be strictly continental. There is a gradual change throughout the Grand Rapids Formation from the marine conditions at the base to the continental conditions at the top with alternations of salinity suggested in the middle portions of the formation.

Regional Correlation of the Mannville Group

The Mannville Group has been correlated with Lower and Middle Blairmore Formations in the southern Foothills; Luscar and Mountain Park Formations in the central Foothills; Gething, Moosebar and Commotion Formations in the Pine River area, British Columbia; "Bullhead", Loon River and Peace River Formations in the lower Peace River area, Alberta; and Garbutt and Scatter Formations in the Liard River area, British Columbia (see Figure 5). However, Commotion Formation in the Pine River area and Peace River Formation in the Lower Peace River area are considerably younger in age than the Grand Rapids Formation of the Edmonton - McMurray area.

Lower Mannville Strata

The top of the Lower Mannville strata is marked by the widespread ostracode-bearing "Calcareous" Member (Glaister, 1959). The base of the Upper Mannville strata is marked by a persistent glauconitic sandstone known as Wabiskaw Member in Edmonton - McMurray area, Bluesky Member in the

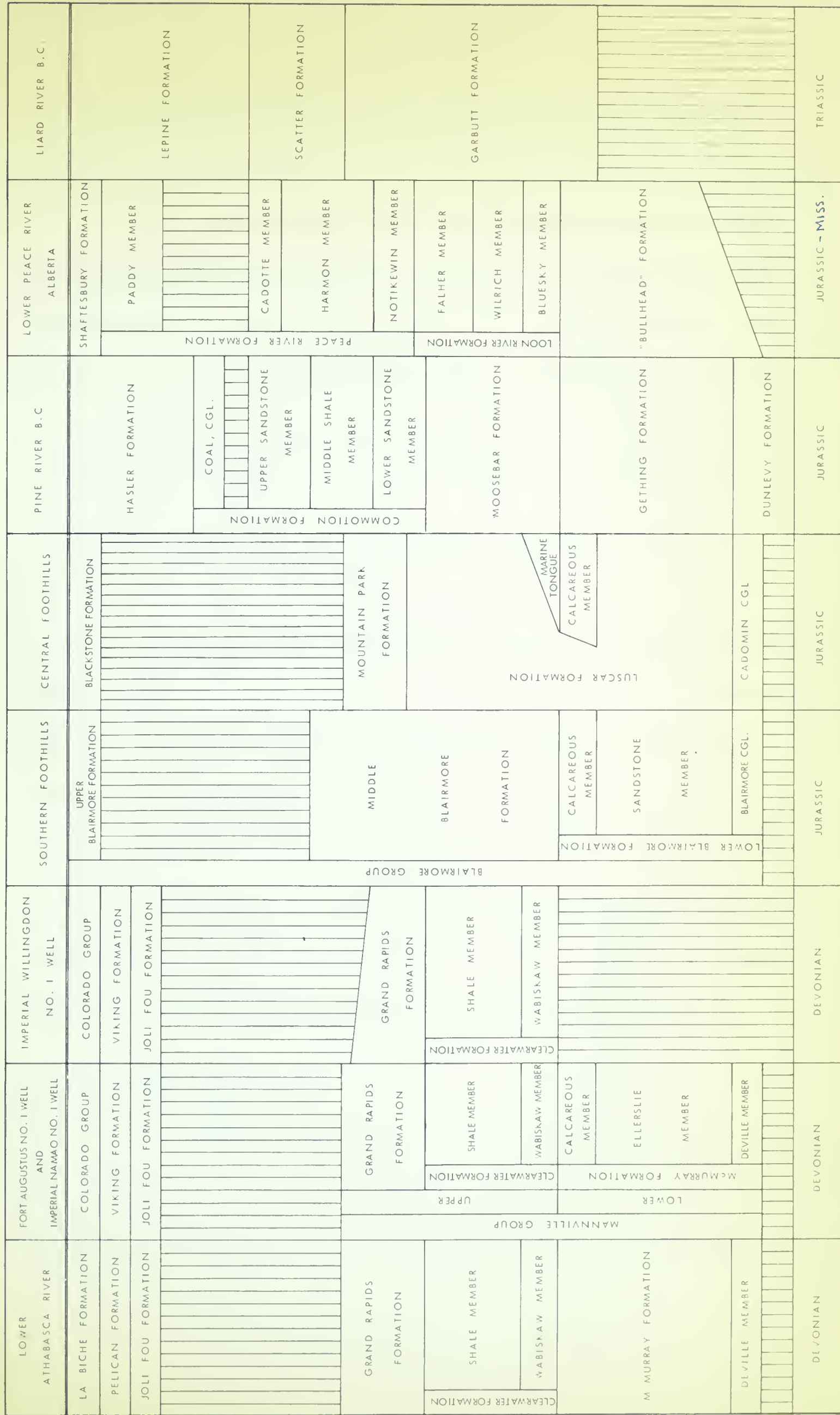


FIGURE 5. CHART SHOWING THE CORRELATION OF MANVILLE GROUP IN ALBERTA AND NORTHEASTERN BRITISH COLUMBIA.

lower Peace River area and Moosebar Formation (basal part only) in the Pine River area, British Columbia.

The Lower Mannville strata in the Edmonton - McMurray area consist of the continental McMurray Formation which is correlative with the Lower Blairmore Formation (Glaister, 1959) of the southern Foothills, consisting of a similar sequence of quartzose sandstones, siltstones and varicoloured shales unconformably overlying the coal measures of the Kootenay Formation. The basal Blairmore Conglomerate is correlative with the Deville Member and the upper part of the Lower Blairmore Formation has ostracode-bearing calcareous shale typical of the "Calcareous" Member.

In the central Foothills the lower portion of the Luscar Formation which is below the foraminifera-bearing marine tongue is correlative with the McMurray Formation. Metacypris persulcata has been found here in the "Calcareous" Member and the marine tongue has Middle Albian foraminifera similar to those found in the Clearwater Formation (Mellon and Wall, 1961). The basic twofold division of the Blairmore-Mannville Group, based on the "Calcareous" Member (Glaister, 1959), also applies in the central Foothills. The Cadomin Conglomerate is correlative with the Deville Member.

Upper Mannville Strata

The Upper Mannville strata consist of Clearwater and Grand Rapids Formations in the Edmonton-McMurray area. The Clearwater Formation has the glauconitic Wabiskaw Member at the base, the calcareous foraminifera of

the Marginulinopsis collinsi zone belonging to the neritic facies in the lower portion and the arenaceous foraminifera of the Haplophragmoides gigas minor zone belonging to the shallow-water facies in the upper portion. The latter zone also extends into the base of the Grand Rapids Formation. The Upper Mannville strata are represented by the Middle Blairmore Formation (Mellon and Wall, 1961) of the southern Foothills consisting of a sequence of light to dark green, feldspathic greywackes and siltstones interbedded with a lesser volume of grey, green and mottled red, massive silty shales, the proportion of the latter increasing towards the top. As the boreal flooding did not extend up to the southernmost Foothills, this latter section is entirely continental and the marine facies consisting of the glauconitic Wabiskaw Member and the foraminifera-bearing Clearwater shale are not developed. The rare occurrence of the angiosperm leaf Sapindopsis in the upper portion of the Middle Blairmore (Stelck, pers. comm.) probably indicates that it is slightly younger than the Grand Rapids Formation which lacks angiosperm fossils.

In the central Foothills, the marine tongue, the portion of the Luscar Formation lying above it and the Mountain Park Formation represent the strata equivalent to the Upper Mannville in this area. The 15 to 20 feet thick foraminifera-bearing marine tongue represents the reduced Clearwater marine facies of the central Plains.

In the Pine River area the Moosebar and lower part of Commotion Formations constitute the approximate equivalents of the Upper Mannville strata.

The upper portion of the Commotion Formation is distinctly younger than the Grand Rapids Formation as its flora is dicotyledonous. The Moosebar Formation represents the marine facies with glauconitic sandstone at the base and is equivalent to the Clearwater Formation.

The Loon River and the Peace River Formations of the Lower Peace River are approximately correlative with the Upper Mannville strata. However, the upper portion of the Peace River Formation consisting of the Cadotte and Paddy Members is younger than the Grand Rapids Formation. Cadotte Member consists of glauconitic sandstone with minor shale interbeds, and carries the Gastrolites fauna, belonging to the cristatum zone (top of the Middle Albian in the Gault clay of England). Paddy Member consists of white to black silty, carbonaceous, fine-grained continental sandstone and overlies Cadotte Member disconformably (Wickenden, 1951 and Stelck, 1958). Harmon Member belonging to the Haplophragmoides multiplum zone (Stelck, Wall et al., 1956) consists of dark grey slightly silty marine shale and lies between the Subarcthoplites (lower Middle Albian) and the Gastrolites (uppermost Middle Albian) zones and is therefore considered to be the time equivalent of the Grand Rapids Formation. Notikewin Member consists of fine-grained, usually glauconitic sandstone with interbeds of light to dark grey shales. It is correlative with the lower portion of the Grand Rapids Formation as the Haplophragmoides gigas minor which extends into the basal portion of the Grand Rapids Formation is found up to the top of the Notikewin Member. The Loon River Formation is equivalent to the Clearwater Formation. The Bluesky

Member consisting of the glauconitic sandstone is equivalent to the Wabiskaw Member. The rest of the Loon River marine shales (Wilrich and Falher Members) carry calcareous foraminifera belonging to the Marginulinopsis collinsi zone in the lower portion and the arenaceous foraminifera belonging to the Haplophragmoides gigas minor zone in the upper portion. These foraminifera are associated with the ammonite Subarcthoplites mcconnelli (Whiteaves), belonging to the lower Middle Albian age, in the outcrops of the Clearwater and Loon River shales in northern Alberta.

In the Liard River area the Garbutt Formation consisting of marine shale perhaps represents the thickening of the Clearwater marine facies toward north. The overlying Scatter Formation consisting of marine sandstone perhaps indicates shallowing of the sea as a result of the increased rate of sedimentation.

Lithologic Homotaxy

From a regional point of view a twofold division of the Mannville and of the Lower and Middle Blairmore beds appears to be suitable. Mellon and Wall (1961) outline a lower sequence of quartzose sandstone with a calcareous ostracode-bearing member at the top, and an upper sequence of feldspathic greywacke and feldspathic and chloritic arkoses with a basal sandstone which becomes increasingly glauconitic to the north. The upper division consisting of Upper Mannville (Middle Blairmore) strata undergoes a regional facies change from a shoreline and marine environment of deposition in the north which introduces the glauconitic sandstone and foraminifera-bearing shales, to the non-marine, fluvial environment of deposition in the south

with feldspathic greywacke and chloritic arkoses deposited under continental conditions. The sandstones of the Grand Rapids Formation deposited under near-shore and continental conditions in the north have the same lithologic and petrographic properties as those belonging to the continental facies in the south.

Age of the Mannville Group

The Mannville Group belongs to the Lower Cretaceous Series (Barremian to Middle Albian) on faunal, palaeobotanical and palynological evidence.

Lower Mannville Strata

The evidence for a Middle Albian age for the "Calcareous" Member and the uppermost McMurray Formation in northern Alberta has been accumulating. Mellon and Wall (1956) found the microfauna of the uppermost McMurray Formation to be very similar to the microfauna from the basal Clearwater Formation of Middle Albian age. In the Barnsdall et al. West Wabiskaw No. 1 well (Lsd. 11, Sec. 17, Tp. 78, R. 2, W. 5th Mer.) Mellon and Wall (1961) found an intercalation of marine ostracode Cytheridea bonaccordensis Loranger and arenaceous foraminifera similar to those from the Middle Albian Clearwater shale, with the non-marine Metacypris persulcata fauna from the "Calcareous" Member. This leads them to conclude that the "Calcareous" Member is of early Middle Albian age in central and north-central Alberta.

On palynological evidence it appears that the Ellerslie and Deville Members are of Barremian-Aptian age. The microfloral assemblage of these

members is very similar to that of the Weald Clay (Barremian to lower part of Aptian). Many of the microspore and megaspore species making their entrance during the Barremian and the basal Aptian Stages in the English Wealden and in other parts of the world are present in the Deville and Ellerslie Members.

The fauna contained in the Lower Mannville strata of non-marine to brackish origin are long ranging. Peck (1941) considers many of the ostracode species of the "Calcareous" Member as younger than Portlandian (Upper Jurassic) but older than Upper Cretaceous. The presence of Metacypris pahasapensis Roth which is diagnostic for the Wealden 4 zone (Lower Berriasian) in northern Germany, within the "Calcareous" Member, has been considered by Gussow (1960) as an evidence for similar age for this member. However, M. pahasapensis has also been recorded from the upper portion of the Vanguard Formation (Upper Jurassic) by Klingspor (1958) and appears to be too long ranging to be of any stratigraphic significance.

Mitchell (1949) recorded a belemnite Pachyteuthys densus of Upper Jurassic age from the Deville Member. This belemnite fossil could be derived.

Upper Mannville Strata

The Upper Mannville beds are relatively easy to date due to the occurrence of ammonites which permit accurate correlation with the standard European faunal zones. The microfossils recovered from the marine facies of the Upper Mannville have been reported by Nauss (1947) from the Cummings Member at Vermilion in east-central Alberta, by Wickenden (1951) from the Loon River Formation of the Lower Peace River area, by Mellon and Wall (1956)

from the Upper McMurray and basal Clearwater Formations of the McMurray area, by Stelck, Wall et al. (1956) from Athabasca and Peace River areas and by Mellon and Wall (1961) from Cadomin outcrop in the central Foothills and from the Edmonton-McMurray and Wabiskaw areas. This microfauna, consisting of the lower Marginulinopsis collinsi zone and the upper Haplophragmoides gigas minor zone, is widespread in western Canada and belongs to the lower part of the Middle Albian Substage as it is associated with Subarcthoplites mcconnelli (Whiteaves) of lower Middle Albian age, in the outcrops of the Clearwater and Loon River shales in northern Alberta.

Since no angiosperm pollen or megaf flora have been found in the Grand Rapids Formation it is considered to be older than the late Middle Albian Commotion flora.

The megafauna, microfauna and megaf flora reported from the three wells, that were studied in central Alberta are listed below:

Megafauna

Williams (1960) reports the following megafauna from Imperial Namao No. 1 well.

Wabiskaw Member

Murraia naiadiformis Russell

Pinna? sp.

Eupera cf. E. onestae (McLearn)

Scalez sp.

"Calcareous" Member

Viviparus murrei Russell

Melania multorbis Russell

Onestia? sp.

Murraia sp.

Sphaerium sp.

Corbula? cf. C. palliseri McLearn

Solecurtis? sp.

Ellerslie Member

Astarte natosini McLearn

Melania multorbis Russell

Microfauna

Mellon and Wall (1961) report the following microfauna from Anglo-Home-C. and E. Fort Augustus No. 1 well.

"Calcareous" Member

Bairdiocypris albertensis Loranger

Candona stirlingensis Loranger

Cythereis calmontensis Loranger

Cythereis inflata Loranger

Metacypris angularis Loranger (non Peck)

Metacypris persulcata Loranger (non Peck)

Clearwater and Grand Rapids Formations

Ammobaculites fragmentaria Cushman

Ammomarginulina cf. A. obliquus Loeblich and Tappan

Gaudryina cf. G. hectori Nauss

Haplophragmoides gigas minor Nauss

Haplophragmoides sp.

Miliammina sproulei Nauss

Miliammina subelliptica Mellon and Wall

Proteonina sp.

Reophax sp.

Psamminopelta cf. P. bowsheri Tappan

Trochammina sp.

Verneuilinoides cummingensis (Nauss)

Globulina lacrima canadensis Mellon and Wall

Globulina sp.

Marginulinopsis collinsi Mellon and Wall

Quadrимorphina albertensis Mellon and Wall

Williams (1960) reports the following microfauna from Imperial

Namoo No. 1 well.

Clearwater shale above the Wabiskaw Member

Ammobaculites humei Nauss

Bathysiphon sp.

Nodosinella sp.

Pseudonodosaria clearwaterensis Mellon and Wall

Saracenaria projectura Stelck and Wall

Dentalina sp.

Globulina lacrima canadensis Mellon and Wall

Marginulinopsis collinsi Mellon and Wall

Tritaxia athabascensis Mellon and Wall

Haplophragmoides gigas minor Nauss

Only the shallow-water arenaceous foraminifera were recovered from the Imperial Willingdon No. 1 well which is situated on the western flank of the Wainwright Ridge. This suite reported here for the first time is as follows:

Grand Rapids Formation

Miliammina sproulei Nauss

Verneuilinoides cummingensis (Nauss)

Ammobaculites sp.

Clearwater shale above the Wabiskaw Member

Haplophragmoides gigas minor Nauss

Haplophragmoides sluzari Mellon and Wall

Ammobaculites humei Nauss

Eggerella sp.

Leptodermella sp.

Psamminopelta cf. P. bowsheri Tappan

Miliammina sproulei Nauss

Tritaxia athabascensis Mellon and Wall

Reophax sp.

Trochammina sp.

Ammodiscus sp.

Megaflora

Williams (1960) reports the following megaflora from Imperial
Namac No. 1 well,

Ellerslie Member

Pityophyllum nordenskjoeldii (Heer) Krystofovich

Sphenopteris sp.

A more extensive flora has been collected by Dr. G. B. Mellon and
identified by Prof. C. R. Stelck from the Anglo-Home-C. and E. Fort Augustus
No. 1 well from the Grand Rapids Formation between 2469 and 2555 feet
drilling depth.

Grand Rapids Formation

Sphenopteris brulensis Bell

Cladophlebis sp.

Sagenopteris cf. S. elliptica Fontaine

Ptilophyllum cf. P. hirtum Bell

Ptilophyllum montanense (Fontaine)

Nilssonina canadensis Bell

Cyparissidium? cf. C.? gracile? Heer in Bell

Athrotaxites berryi Bell

Pagiophyllum ambiguum (Heer) Seward

A few plant fossils were collected by the writer from the Grand
Rapids Formation in the Imperial Willingdon No. 1 well between the drilling
depths of 1846 and 1881 feet which are listed below:

Grand Rapids Formation

Athrotaxites berryi Bell

Sphenopteris cf. Ruffordia goepperti (Dunker) Seward

CHAPTER THREE - PALYNOLOGICAL ZONES AND AGE OF THE WEALDEN IN NORTHWESTERN EUROPE

The stratigraphic position of the English Wealden has been a topic of interesting controversy in the past. Due to the absence of stratigraphically diagnostic fauna and megafloora in these continental beds, it was not possible to date them precisely. In the earlier stages the English Wealden was assigned to the Jurassic System (Seward, 1895, p. 240; Strahan, 1898, p. 74) under the false impression of its so-called relict fauna and flora of Jurassic affinity. It is now, however, generally accepted as part of the Cretaceous. The present controversy is, as to whether the English Wealden occupies an entirely pre-Valanginian position as proposed by Wolberg (1949, 1950) or it represents a complete record of the Berriasian-Barremian times as suggested by Allen (1955), Gignoux (1955) and Hughes (1958). Recently Gussow (1960) and Pocock (1962) have used the ostracode and palynological zones of the Wealden in northwestern Europe to determine the stratigraphic position of the Mannville Group in Alberta. In this respect, the geological set up during the Lower Cretaceous in western Europe and the true stratigraphic position of the English Wealden have a direct bearing on the present problem.

The lower boundary of Cretaceous in Europe is defined by the emergence that took place in most of the continent at the end of Jurassic Period. Three broad depositional environments can be recognized in western Europe during the Neocomian.

1. Tethys-Alpine Region

1. The Alpine Region

The Alpine region is a vast area of high mountains and deep valleys, extending from the Pyrenees in the west to the Ural Mountains in the east. It is a region of great natural beauty and of great importance to the world. The Alps are the highest and most extensive mountain range in Europe, and they are a source of many of the world's great rivers. The Alpine region is also a source of many of the world's great cities and of many of the world's great works of art. The Alpine region is a region of great natural beauty and of great importance to the world. The Alps are the highest and most extensive mountain range in Europe, and they are a source of many of the world's great rivers. The Alpine region is also a source of many of the world's great cities and of many of the world's great works of art.

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The geosynclinal pattern consisting of linear troughs separated by growing positive belts of the late Jurassic continued into the Cretaceous time in the Alpine region. The marine conditions continued from Jurassic into Lower Cretaceous in this area.

2. Anglo-Paris Basin

The regressive facies of the uppermost Jurassic marked a retreat of the seas from Europe, both toward the north and southward to the Tethys. In the earliest Cretaceous time many of the old massifs became emergent and much of the north-central Europe, England, western France and Spain became land.

During this period the Anglo-Paris Basin was separated from the Northern Basin (see Figure 6A) by London-Ardenne Ridge which extended up to the Harz massif, and from the Tethys-Alpine region by Morvan-Vosges Hercynian massifs. This resulted in an isolated fresh-water to brackish restricted environment. The Berriasian, Valanginian, Hauterivian, Barremian and partly Aptian (if the recticostatus Zone is included in Aptian Stage in Spath's sense) Stages are represented in the English Wealden in southern England by a thick series of continental beds comprising in the lower portion the Hastings Sands which is a fluvial or deltaic lacustrine alluvium, and at the top the brackish Weald Clay. The Weald Clay shows an increasing saltwater influence as one ascends the succession. Towards the top it is of near-marine facies and contains foraminifera and echinoid spines. During the Hauterivian Stage a marine transgression took place from the Tethys Sea into the Anglo-Paris Basin which deposited marine

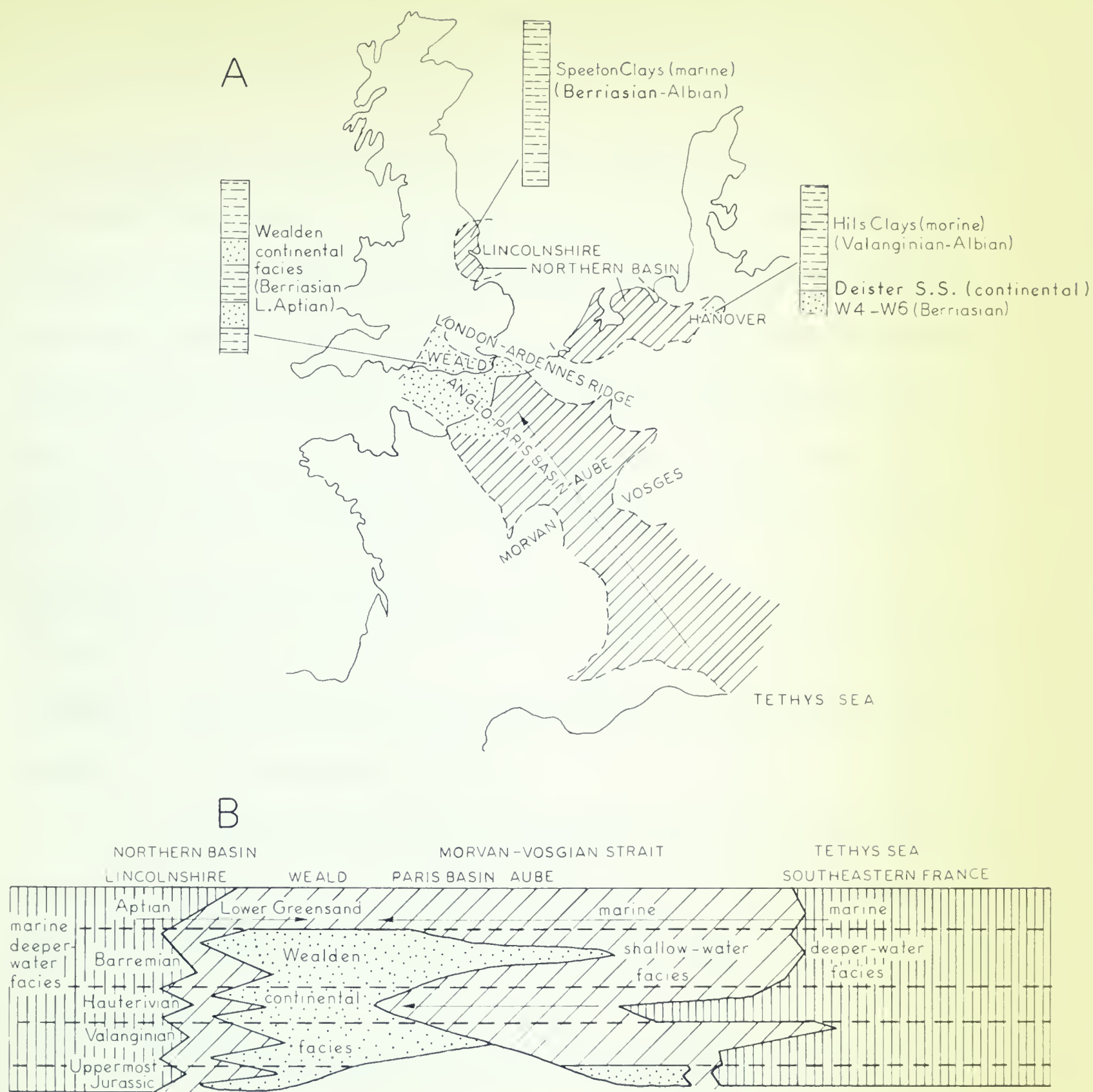


Figure 6.

A. Distribution of marine and Wealden facies of Neocomian in northwestern Europe (Modified from P. Allen, 1955).

B. Diagrammatic reconstruction of Lower Cretaceous facies between northern England and southeastern France (Modified from M. Gignoux, 1955).

limestones and clays in the Paris Basin, while the continental conditions in the southern England were altered to brackish environment. The change from the continental Hastings Sands to brackish Weald Clay took place during the Hauterivian time as the water level rose in the Wealden swamps. During the Barremian Stage a regression took place which extended the continental to brackish environment from the southern England to the Paris Basin and Aube (see Figure 6B). The main marine transgression took place during the Aptian Stage which joined the Northern Basin with the Tethys Sea through the Anglo-Paris Basin. The Wealden sediments were covered by the glauconitic Lower Greensand containing Deshayesites deshayesi of Lower Aptian age. These in turn were covered during Middle and Upper Albian by the thick blue clays of Gault with abundant ammonites, especially Hoplites. Opposite the Folkestone cliffs Spath (1923-43) distinguished a whole series of ammonite zones, which have been used for world-wide correlations.

The fauna of the Tethyan Province was distinct from that of the Northern Province but it assumed a cosmopolitan character after the Northern Basin was joined with the Tethys Sea during Lower Aptian.

3. Northern Basin

An epicontinental sea existed in the northern Europe at the end of Jurassic and the beginning of Cretaceous and covered all the northern part of the North Atlantic continent. Most of these deposits are covered by the North Sea and Arctic Ocean at present, except in the Lincolnshire and Yorkshire area in northern England, Holland and northern Germany.

Northern England, Lincolnshire and Yorkshire

The Lower Cretaceous is exposed in a single fine section in the cliffs of Speeton. The entirely marine Speeton Clays represent the whole Lower Cretaceous in which the ammonite zones were established by Spath (1924). Berriasian is distinguished by Tollia. Valanginian is distinguished by the presence of Polyptychites and Barremian by Simbirskites both belonging to the Northern Faunal Province. During Aptian when the Northern Basin was connected with the Tethys Sea through Anglo-Paris Basin the widespread ammonite Deshayesites deshayesi is found. The Albian has its customary zones, described in southern England.

Holland and Northern Germany

The hills of Hils in Hanover area have the most extensive outcrops of the Lower Cretaceous in northern Germany. In this area unlike Speeton, continental Deister Sandstone representing Berriasian and perhaps also Lower Valanginian was deposited along the northern flank of the London-Ardennes Ridge at the same time when the Hastings Sands were being deposited along its southern flank. Perhaps the topographic rejuvenation caused by the Purbeck earth movements resulted in the deposition of sands and pebbles in both the basins at the same time and at least the base of the Deister and Hastings Sands are roughly of the same age (Allen, 1955). A marine transgression took place during the Upper Valanginian which deposited the Hils Clays above Deister Sandstone. Hils Clays and Deister Sandstone together are equivalent to the Speeton Clays.

While marine sediments were being deposited in the Northern Basin,

equivalent continental beds were being deposited in the Wealden swamp in the Anglo-Paris Basin.

Hughes (1958) established a microfloral correlation between the English Wealden, equivalent marine beds in Lincolnshire area, and the Wealden of Holland and northern Germany (see Figure 7). Only the megaspores of Verrutrilletes flora (Berriasian Stage) and the Thomsonia flora (Valanginian Stage) present in the Weald outcrop have been found in the Wealden of Holland (Dijkstra, 1951). The German Wealden contains only the lower part of the Thomsonia flora (Madler, 1954), which belongs to the Wealden 4/5 of the Thoren area. The Arcellites (=Pyrobolospora) flora (Barremian-Aptian) of the Weald Clay is not represented in the equivalent marine beds of the Northern Basin in Lincolnshire, Holland and northern Germany. This microfloral correlation confirms the stratigraphic conclusions drawn by Gignoux (1955) and Allen (1955) concerning the time equivalence of the marine beds of the Northern Basin with the continental Wealden beds, on the basis of lithofacies distribution.

Age of the Wealden

Seward (1895, p. 240) commenting on the Wealden megaf flora stated: "the evidence of palaeobotany certainly favours the inclusion of the Wealden rocks in the Jurassic series." However, with very few exceptions the plant macrofossils described by Seward were confined to the Fairlight Clay (Berriasian) at the very base of Wealden. The "Jurassic affinities" of these plant fossils belonging to the Berriasian Stage should not be confused with or be considered representative of the whole Wealden flora. Couper (1958) and Hughes (1955) have

described the plant microfossils from the English Wealden which have also been reported from Berriasian to Aptian Stages of Russia (Bolkhovitina, 1953, 1956, 1959a, 1959b, 1961; Samojlovitch and Mchedlishvili, 1961), Australia (Cookson and Dettmann, 1958a, 1958b) and North America (Groot and Penny, 1960; Pocock, 1962). The Wealden vegetation appears to be intermediate in character between typical Jurassic and typical Upper Cretaceous angiospermous vegetation.

Wicher (1940), Wolberg (1949, 1950) and Grekoff (1953) divided the German "Wealden" into six major ostracode zones called "Wealden 1" to Wealden 6 upwards. "Wealden" 1, 2 and 3 are Middle and Upper Purbeck in age. The use of the name "Wealden" in this case is not justified because Wealden is a rock term applicable only to the non-marine facies developed from Berriasian to Barremian or lowermost Aptian times. The German "Wealden" 1, 2 and 3 should be labelled as Middle and Upper Purbeck to avoid confusion.

Wealden 4 zone (Lower Berriasian) in northern Germany is based on an ostracode fauna containing Metacypris pahasapensis. Wolberg (1949, 1950) examined an ostracode fauna from near the top of Weald Clay at Berwick, Sussex and found forms closely allied to the characteristic species of German Wealden 4 zone. He, therefore, correlated the top of the Weald Clay with the Wealden 4 (Lower Berriasian) of Germany. Not only would such a correlation move the whole English Wealden down to pre-Valanginian position, but it would also entail an enormous time-gap representing Valanginian, Hauterivian, and Barremian between the Weald Clay and the Lower Greensand of Aptian and Lower

Albian age. Casey (1961) who examined the contact of the Lower Greensand and the Wealden Beds in detail feels that there are signs of disconformity but no indication of a lengthy break at this level. In fact, the Weald Clay anticipates the Aptian marine transgression by passage beds containing brackish to marine fauna (e.g. foraminifera, echinoid spines, Mytilus, Ostrea etc.). The presence of derived Kimmeridgian Pavlovia both in the Lower Greensand and in the top of the Wealden Shales indicates that the disconformity, where present, is only of a minor nature. On petrological basis the lithofacies can be extended from the Weald of Sussex to Paris Basin where the marine beds representing the Hauterivian transgression with ammonite fossils facilitate a more accurate dating of the whole section. It indicates that strata, both older and younger than Hauterivian, are present in the English Wealden. Also the microfloral correlation between the English and German Wealden (Hughes, 1958) is not in accord with the correlation proposed by Wolberg (1949, 1950).

CHAPTER FOUR - STRATIGRAPHIC PALYNOLOGY OF THE MANNVILLE GROUP

The "index species" of spores and pollen, with restricted stratigraphic range and intercontinental distribution are very useful for long-range correlations. However, since the environmental conditions are not favourable all over the world at the same time, a species may appear earlier where conditions are favourable, and may make a late appearance in those parts of the world where environment suitable for such migration becomes available at a later time. Climatic and ecologic changes may cause a species to become extinct in one part of the world and force it to migrate to some other part of the world where it may survive for a longer period of time. The environmental and geographic barriers hinder a uniform distribution of species and restrict them to definite areas of the world. Therefore, it is necessary to establish the total geologic range, the entrance level and the acme or peak zone for each "index species" from a large number of localities distributed all over the world. The upper limit of the geologic range of a species is often deceptive due to reworking. When many "index species" with known stratigraphic ranges and entrance levels are found in a bed, its age can be ascertained with a greater degree of certainty.

Contamination of the younger microfloral assemblages by the older ones as a result of reworking is quite common due to the minute size of the pollen and spores. Every sand size rock fragment can carry from 10 to 15 spores protected and covered within it. Balme (1957) reports a heavy contamination by well preserved Permian microspores of the Upper Jurassic microfloral assemblage. Yorath (1962) found a heavy contamination of the Upper Jurassic and Lower

Cretaceous (Deer Bay Formation, Arctic Islands) microflora by the Upper Palaeozoic spores. Pocock (pers. comm.) has found a high percentage of Palaeozoic spores in the samples of Lower Cretaceous age in northern Alberta. The writer has also come across a few Palaeozoic forms e.g. Endosporites, Angulisporites, Murospora etc. within the Mannville Group. When the time interval is wide enough the older contaminating species can be easily detected, but when the age difference is not significant it becomes very difficult to decide as to whether the occurrence of a slightly older species is due to reworking or a long time-range. In the case of the Mannville Group the Jurassic microflora could be easily recycled into the Lower Mannville beds and the Lower Mannville species into the Upper Mannville. This would be especially true in the case of the Grand Rapids Formation which is of deltaic origin.

The geological ranges of the "index species" with wide geographic distribution are not sufficiently narrow to be restricted within a member of the Mannville Group. Therefore, in order to eliminate the possibility of misinterpretation as a result of reworking or the continuance of older "index species" at younger horizons, following interpretive approach has been made:

1. Only the entrance levels of the youngest "index species" have been used to determine the age of a member. The entrance level is defined as the oldest known horizon at which a species makes its first appearance in the geologic column. "First appearance" on the other hand simply means the first appearance of a species in a particular section. Often when the older beds are missing long-ranging older species make their "first appearance" at younger horizons.

2. "Index species" with local as well as world-wide distribution which characterize a member or a formation by being restricted to it or by being drastically reduced in the overlying strata have been listed for the convenience of local correlations.

A comparison of the number of species common to the Mannville and the overall Wealden microfloral assemblages has not been made. The writer is not in agreement with this procedure of correlation adopted by Pocock (1962) because most of the species common to the two assemblages have a long geological range. Therefore, any finer stratigraphic conclusions drawn on the basis of the "similarity" of the two assemblages would be deceptive.

No statistical studies, based on the changes in relative abundance of selected species groups of spores and pollen, has been made. Such studies are used only for local correlations and reflect important vegetational changes. As no problems concerning local correlations were involved in the present work, and as it was felt that the various members can be more reliably identified by the differences in their specific composition, detailed histograms have not been constructed. Moreover, the effects of any vegetational changes would be difficult to distinguish from the effects of boreal flooding on the microfloral representation in the Upper Mannville strata. However, a rough estimate of the relative abundance of each species in each sample has been recorded on Tables I, II and III (in pocket), which appears to be sufficient for the present purpose. A quantitative estimate of the relative abundance and stratigraphic distribution

of the megaspores in the Mannville Group is given on Table IV.

McMurray Formation

(a) Deville Member

44 species of microspores and pollen and 6 species of megaspores were recorded from the Deville Member. All the 50 species make their "first appearance" in the Deville Member as it overlies the Palaeozoic rocks unconformably in central Alberta. However, their "first appearance" should not be confused with their entrance level in Lower Cretaceous. There are indications that the Berriasian to Hauterivian Stages are probably not represented at the base of the Mannville Group in central Alberta, contrary to the conclusions of Pocock (1962).

The "index species" of the Deville Member can be divided into five groups on the basis of their stratigraphic significance.

Group 1a

Trilobosporites hannonicus (Delcourt and Sprumont) Potonie, entrance level: Aptian? of Belgian "Wealden".

Pilosporites verus Delcourt and Sprumont, entrance level: Aptian? of Belgian "Wealden".

Couperisporites complexus (Couper) Pocock, entrance level: Barremian of English Wealden.

Dijkstraisporites helios (Dijkstra) Potonie, entrance level: Upper Barremian of English Wealden.

Arcellites disciformis Miner (? = Pyrobolospira hexapartita Hughes), entrance level of P. hexapartita, which resembles A. disciformis so closely that the

two are probably conspecific, is in the Upper Barremian (Wealden Marls) of the English Wealden. A. disciformis itself has not been reported from beds older than Cenomanian (Dakota Formation of Iowa) before this.

Group 2a.

Appendicisporites tricornitatus Weyland and Greifeld, entrance level: Top of Berriasian in Fairlight Clay of the English Wealden.

A. crimensis (Bolkhovitina) Pocock, entrance level: Hauterivian, Crimea, Russia.

Cicatricosisporites mediotriatus (Bolkhovitina) Pocock, entrance level: Hauterivian, Crimea, Russia.

Trilobosporites apiverrucatus Couper, entrance level: Berriasian in the Fairlight Clay of the English Wealden.

Concavissimisporites punctatus (Delcourt and Sprumont) n. comb., entrance level: Berriasian in the Fairlight Clay of the English Wealden.

Maexisporites obolus (Dijkstra) Potonie, entrance level: Hauterivian of the English Wealden.

Group 3a.

Schizosporis reticulatus Cookson and Dettmann, entrance level: Neocomian of South Australia.

S. parvus Cookson and Dettmann, entrance level: Albian in South Australia.

The 13 "index species" listed above make their entrance during the Lower Cretaceous. Their presence in the Deville Member is a conclusive evidence of its Lower Cretaceous age.

The 5 species listed under group 1a consist of younger species which

make their entrance during the Barremian-Aptian? time. They appear in the upper part of the Deville Member, which probably represents their entrance level. However, their very presence is sufficient to indicate a Barremian age for the Deville Member.

The 6 species listed under group 2a consist of slightly older species which make their entrance during the Berriasian - Hauterivian time. Their simultaneous appearance near the base of the Deville Member indicates that they merely represent a continuance of the older species which make their entrance during the Berriasian, Valanginian and Hauterivian Stages. As these older stages are probably not represented at the base of the Mannville Group, they appear simultaneously at the base of the Deville Member.

The association of abundant Dijkstraia helios with Arcellites disciformis (? - Pyrobolospira hexapartita) and Arcellites rugosus n. sp. in the Deville Member indicates that only the Arcellites (=Pyrobolospira) flora (Hughes, 1958) belonging to the Barremian and the lower part of the Aptian Stage, in the English Wealden is represented in this member. The older Thomsonia flora (Valanginian) and the Verrutrites flora (Berriasian) of the English Wealden are not represented at the base of the Mannville Group (see Figure 7). This further supports the theory that the base of the Mannville Group in central Alberta is probably not older than Barremian.

Group 4a

Appendicisporites cooksonii (Balme) Pocock, known range: Callovian to Upper Albian in Western Australia.

Dictyotriletes pseudoreticulatus (Couper) Pocock, known range: Upper Purbeck to Lower Cretaceous.

Staplinisporites caminus (Balme) Pocock, known range: Oxfordian to Aptian in Western Australia.

Pilosporites trichopapillosus (Thiergart) Delcourt and Sprumont., known range: Upper Purbeck to Lower Cretaceous.

All the "index species" belonging to group 4a make their entrance during the Jurassic but continue into the Lower Cretaceous. All the species in this group except Pilosporites trichopapillosus are more or less restricted to the Lower Mannville strata. Their rare occurrences in the Upper Mannville beds are presumably due to reworking. The association of these older forms from Jurassic with the younger species which make their entrance during the Lower Cretaceous points to the close relationship of the microflora of the Deville Member to those of Jurassic strata.

Group 5a

This group consists of the "index species" which have not been reported from outside western Canada so far. All the species listed below make their probable entrance in the Deville Member.

Appendicisporites jansonii Pocock*

A. erdtmanii Pocock

Trilobosporites canadensis Pocock

Concavissimisporites parkinii (Pocock) n. comb.

Rouseisporites reticulatus Pocock *

Cooksonites variabilis Pocock

C. reticulatus Pocock *

Cedripites canadensis Pocock *

Equisetosporites concinnus n. sp.

Arcellites rugosus n. sp.

* unreported from Deville by Pocock (1962)

(b) Ellerslie Member

95 species of microspores and pollen and 16 species of megaspores were recorded from the Ellerslie Member. Of these, 66 species make their "first appearance" in this member in central Alberta. Of the 50 species recorded from the Deville Member only five do not persist into the Ellerslie Member. Out of these 5 species two are records of occurrences of single specimens in the Deville Member, and the remaining 3 species reappear in the Upper Mannville strata. The absence of these 3 species from the Ellerslie Member is because of their rare occurrence and does not have any stratigraphic significance. The microfloral assemblages from the Deville and Ellerslie Members are basically very similar and although a large number of species appear for the first time in the Ellerslie Member nearly all the species from the Deville Member continue into the Ellerslie Member. There does not appear to be any significant age difference between them, based on the entrance levels for index species.

The "index species" of the Ellerslie Member can be divided into four groups on the basis of their stratigraphic significance.

Group 1b

Appendicisporites cf. A. pschekhaensis (Bolkhovitina) Pocock, entrance level:

Neocomian, Russia.

Cicatricosisporites perforatus (Baranov et al.) n. comb., entrance level: Aptian in Siberia, U.S.S.R.

Trilobosporites trioreticulosus Cookson and Dettmann, entrance level: Aptian in eastern Australia.

The 3 species listed above under group 1b make their entrance in the Ellerslie Member. The 5 species listed under group 1a of the Deville Member viz. Trilobosporites hannonicus, Pilosisporites verus, Couperisporites complexus, Dijkstraisporites helios and Arcellites disciformis are also present in the Ellerslie Member. These species make their entrance during the Barremian-Aptian? Stages.

Group 2b

Taurocusporites segmentatus Stover, known range: Lower Cretaceous, Maryland, U.S.A.

Aequitriradites spinulosus (Cookson and Dettmann) Cookson and Dettmann, known range: Neocomian to Albian, eastern Australia.

Parvisaccites radiatus Couper, entrance level: Berriasian in Fairlight Clay of the English Wealden, peak zone: Barremian-Aptian in the Weald Clay, Weald Shales and Lower Greensand.

Verrucosisporites asymmetricus (Cookson and Dettmann) Pocock, known range: ? -Albian in eastern Australia.

Maexisporites soldanellus (Dijkstra) Potonie, known range: Berriasian to the lowermost Aptian in the English Wealden.

Horstisporites reticuliferus (Dijkstra) Potonie, known range: Neocomian in the Wealden of Netherlands.

All the 6 "index species" listed above make their entrance during the Lower Cretaceous. They make their "first appearance" in the Ellerslie Member. The 6 species listed under group 2a of the Deville Member viz. Appendicisporites tricornitatus, A. crimensis, Cicatricosisporites mediotriatus, Trilobosporites apiverrucatus, Concavissimisporites punctatus and Maexisporites obolus, and Schizosporis reticulatus from the group 3a are also present in the Ellerslie Member. Most of these species make their entrance during the Berriasian to Hauterivian time and range into younger horizons.

The 21 "index species" listed above under the groups 1b and 2b make their entrance during the Lower Cretaceous. Their presence in the Ellerslie Member is a conclusive evidence of its Lower Cretaceous age.

Group 1b contains 2 species which make their entrance during the Aptian Stage, the remaining species make their entrance during the Barremian-Aptian? time. Moreover, the association of the abundant Arcellites disciformis (? = Pyrobolospora hexapartita) with Dijkstraisporites helios, Arcellites rugosus and Arcellites incipiens within the Ellerslie Member indicates that this member too, like the Deville Member represents the upper Wealden Arcellites (= Pyrobolospora) flora of Barremian and lowermost Aptian age (Hughes, 1958). On the basis of this microfloral evidence an approximately Barremian-Aptian age is assigned to the Ellerslie Member.

Group 3b

Cicatricosisporites dorsostriatus (Bolkhovitina) n.comb., known range: Middle Jurassic to Aptian, Russia.

The 4 species listed under group 4a of the Deville Member viz. Appendicisporites cooksonii, Dictyotriletes pseudoreticulatus, Staplinisporites caminus and Pilosporites trichopapillosus are also present in the Ellerslie Member. These 5 species make their entrance during the Jurassic but range into Lower Cretaceous. Except Pilosporites trichopapillosus, which appears to have a more or less uniform distribution throughout the Mannville Group, the rest of the species do not range into the Upper Mannville. Their upper limit seems to lie within the Lower Mannville strata.

Group 4b

This group consists of the "index species" which have not been reported from outside western Canada so far. All the species listed below make their probable entrance in the Ellerslie Member.

Hymenozonotriletes mesozoicus Pocock

Aequitriradites variabilis Pocock

Rouseisporites laevigatus Pocock

R. triangularis Pocock

Cedripites cretaceus Pocock *

Podocarpidites ornatus Pocock

P. canadensis Pocock *

Arcellites incipiens n. sp.

* reported from Deville by Pocock

The 10 species listed under group 5a of the Deville Member viz.

Appendicisporites jansonii, A. erdtmanii, Trilobosporites canadensis,
Concavissimisporites parkinii, Rouseisporites reticulatus, Cooksonites
reticulatus, C. variabilis, Cedripites canadensis, Equisetosporites concinnus
 and Arcellites rugosus also range into the Ellerslie Member.

(c) "Calcareous" Member

32 species of microspores and pollen, 3 species of marine micro-plankton and 1 species of megaspore constitute the microfloral assemblage of the "Calcareous" Member. No new species, except the three marine micro-plankton make their appearance in this member. Of the 111 species recorded from the Ellerslie Member only 33 species continue into the "Calcareous" Member. There is a distinct decline in both the abundance and variety of the microflora. This probably resulted due to a rise in the water level of the lakes in advance of the main boreal transgression. This rise in the level of the fresh-water to brackish shallow lakes and lagoons probably lead to a widespread submergence and destruction of the thick lowland vegetation that flourished during the deposition of the underlying Ellerslie Member. In these widespread lakes the rich ostracode and the molluscan faunas of the "Calcareous" Member originated. The spores and pollen of the "Calcareous" Member were partially contributed by the surviving flora and partially transported into the lakes by wind and water from the other areas.

The 3 species of marine microplankton which make their "first appearance" near the top of the "Calcareous" Member in the Imperial Namao No. 1 well are:

		LINCOLNSHIRE	E. HOLLAND	N. GERMANY	BELGIUM	PALYNOLOGICAL ZONES					
		WEALD OUTCROP				MICROSPORES	MEGASPORES				
LOWER CRETACEOUS	UPPER ALBIAN	GAULT	SPEETON CLAYS (MARINE)	MARINE	HILS CLAYS (MARINE)	ENTRANCE	MAXIMUM				
	MIDDLE ALBIAN										
	LOWER ALBIAN										
	LOWER ALBIAN	LOWER				GREENSAND	WEALD CLAY	WEALDEN	HASTINGS SANDS	50	
	APTIAN*										
	BARREMIAN										
	HAUTERIVIAN							92	70	ARCELLITES (=PYROBOLOSPORA) FLORA	
VALANGINIAN				21	37	THOMSONIA FLORA					
BERRIASIAN				14		VERRUTRILETES FLORA					
UPPER JURASSIC	UPPER	UPPER PURBECK	CONTINENTAL	DEISTER SANDSTONE	W3 W2 W1	36, 37, 46					
	TITHONIAN	MIDDLE PURBECK				17, 22 36, 41					

FIGURE 7. MICROFLORAL ZONES AND THE CORRELATION OF THE WEALDEN IN NORTHWESTERN EUROPE AND ITS RELATION TO THE MANNVILLE GROUP IN ALBERTA. (MODIFIED FROM ALLEN, 1955 AND HUGHES, 1958).

CENTRAL ALBERTA	PALYNOLOGICAL ZONES		MARINE MICROPLANKTON
	MICROSPORES	MEGASPORES	
MANNVILLE GROUP	JOLI FOU		
	GRAND RAPIDS FM.		
	CLEARWATER FM.	ARCILLITES NUDUS	
	CALCAREOUS MEMBER		
	ELLERSLIE	ARCILLITES (=PYROBOLOSPORA)	
	MEMBER	FLORA	
	DEVILLE MEMBER		

LEGEND

- 1. Appendicisporites perplexus n. sp.
- 2. Conningia colliveri Cookson and Eisenack.
- 14. Appendicisporites tricomitatus Weyland and Greifeld.
- 17. Cicatricosisporites doregenensis Patonite and Gellatich.
- 21. C. brevilecuratus Couper.
- 22. Dictyotrilletes (Klukisporites) pseudoreticulatus (Couper) Pocock.
- 35. Trilobosporites bernisortensis Delcourt and Sprumont.
- 36. T. apivernucatus Couper.
- 37. Concovisimiporites (Concovisporites) punctatus (Delcourt and Sprumont) n. comb.
- 41. Pilosporites trichopapillosus (Thiergart) Delcourt and Sprumont.
- 46. Cingulatisporites voldensis Couper.
- 48. Couperisporites (Cingulatisporites) complexus (Couper) Pocock.
- 49. Cingulatisporites sp.
- 50. C. foveolatus Couper.
- 70. Classopallis torus (Reissinger) Couper.
- 92. Clavatipollenites sp.
- The reticostatus Zone is included in Aptian Stage in Spath's sense.

Palaeoperidinium cretaceum Pocock, known range: Cretaceous.

Pseudoceratium pelliiferum Gocht, known range: Valanginian of northwest Germany to Middle Albian in central Alberta.

Odontochitina operculata (Wetzel) Deflandre, known range: Hauterivian to Upper Cretaceous in northwestern Germany.

The presence of these marine microplankton species near the top of the "Calcareous" Member indicates that probably it is transitional with the overlying marine beds of the Clearwater Formation.

No valid conclusions concerning the age can be drawn on the basis of the microflora contained within the "Calcareous" Member, as no new and stratigraphically significant species make their appearance in this member. The microfloral assemblage, though drastically reduced, is essentially the same as for the Ellerslie Member.

On the basis of microfaunal evidence (Mellon and Wall, 1961), discussed earlier, a Lower Albian to early Middle Albian age is indicated for the "Calcareous" Member.

Lower Mannville Microflora

On the basis of the microfloral evidence the Lower Mannville strata are as old as Barremian at the base. The top is as young as early Middle Albian. The species restricted to the Lower Mannville or older strata on the basis of which it can be distinguished from the Upper Mannville assemblage are: Appendicisporites jansonii, Cicatricosisporites dorsostriatus, Dictyotriletes pseudoreticulatus, Trilobosporites hannonicus, T. canadensis, Pilosisporites verus, Concavissimisporites

punctatus, C. parkinii, Hymenozonotriletes mesozoicus, Staplinisporites caminus, Cooksonites variabilis, C. reticulatus, Parvisaccites radiatus, Podocarpidites ornatus, Equisetosporites concinnus, Horstisporites reticuliferus, Maexisporites soldanellus, M. obolus, Dijkstraisporites helios, Arcellites rugosus and A. incipiens.

Although Appendicisporites cooksonii, Cicatricosisporites perforatus and Arcellites disciformis appear to be restricted to the Lower Mannville in central Alberta, these are long-ranging species. A. cooksonii has been recorded from the Upper Mannville equivalents of Saskatchewan (Pocock, in press), C. perforatus has been recorded from the Colorado Group, Upper Cretaceous (Pocock, pers. comm.) and A. disciformis has been reported from Dakota Formation (Cenomanian) of Iowa (Schemel, 1950 and Hall, 1962).

Clearwater Formation

(a) Wabiskaw Member

69 species of microspores and pollen, 9 species of marine microplankton and 3 species of megaspores were recorded from the Wabiskaw Member. These marine beds can be distinguished from the underlying continental deposits on the basis of abundance and the variety of dinoflagellates, hystrichospheres and undetermined forms of marine microplankton. Of the 111 species recorded from the Ellerslie Member 59 species are present in the Wabiskaw Member, 18 species make their "first appearance" in this member, out of which only 6 species have been reported from outside western Canada.

Whatever vegetational changes were taking place on the land farther

to the south, are only faintly and partially recorded in the deposits belonging to the marine facies of the Upper Mannville. The microflora belonging to these marine beds was transported to the sea by wind and river water. The number of species in the individual samples is very much reduced in the deep-water facies (Shale Member) because of the increase in distance from the land. Pollen distribution is closely linked with the source area and there is a consistent decrease in the total pollen content of the sediments towards the sea. There are very few megaspores in the marine beds but their representation is high in the continental beds of the Lower Mannville and near the top of the Grand Rapids Formation. This is probably because of the larger size of the megaspores due to which they could not be carried farther out in the sea. Many of the Lower Mannville microspore species which are not represented in the marine facies of the Upper Mannville reappear as soon as the continental conditions are restored in the upper portion of the Grand Rapids Formation. Under these circumstances even the rare occurrence of an "index species" in these marine beds shall be significant, because it is likely to reflect its high representation in the source area on the land.

The "index species" of the Wabiskaw Member can be divided into four groups on the basis of their stratigraphic significance.

Group 1c

Appendicisporites trichacanthus (Maljavkina) var. dissectus (Markova) n. comb.,
known range: Albian to Cenomanian, western Siberia, U.S.S.R.

A. cf. Anemia trichacantha (Maljavkina) Markova, known range: Aptian to

Cenomanian, Russia.

Podocarpidites naumovai n. name for Podocarpidites major (Naumova) n. comb.

which is homonymous with Podocarpidites major Couper, 1953, known range:

Lower and Middle Albian near Aral Sea to Cenomanian in the northern Urals.

Group 2c (Microplankton species)

The species of marine microplankton which make their "first appearance" in the Wabiskaw Member are:

Canningia colliveri Cookson and Eisenack, known range: Aptian of northern Queensland and Western Australia.

Hystriosphæridium tubiferum (Ehrenberg) Deflandre, known range: Barremian to Senonian.

H. irregulare Pocock

H. albertense Pocock

Baltisphaeridium sp.

B. multispinosum n. sp.

The last 4 species have not been reported from outside western Canada. Pseudoceratium pelliiferum, Odontochitina operculata and Palaeoperidinium cretaceum continue from the top of the "Calcareous" Member into the Wabiskaw Member. All the 9 species of microplankton recorded from the Wabiskaw Member seem to be restricted to Cretaceous.

Group 3c

The important "index species" which range into the Wabiskaw Member from the Lower Mannville are: Appendicisporites tricornitatus, A. crimensis

A. cf. A. pschekhaensis, Cicatricosisporites mediotriatus, Trilobosporites apiverrucatus, T. trioreticulosus, Couperisporites complexus, Aequitriradites spinulosus and Verrucosisporites asymmetricus. All these species have wide geographic distribution and are restricted to Cretaceous.

Group 4c

The 'index species' listed under this group have not been reported from outside western Canada so far. Two such species which make their entrance in the Wabiskaw Member are: Appendicisporites perplexus n. sp. and Dijkstraisporites triangulatus n. sp. A. perplexus is rare in Wabiskaw Member, abundant in the Shale Member of the Clearwater Formation and the marine lower portion of the Grand Rapids Formation. It dies out in the upper continental portion of the Grand Rapids Formation. A. perplexus is the only microspore species whose representation in the marine facies of the Upper Mannville is markedly increased instead of being decreased.

Other species restricted to western Canada which persist into the Wabiskaw Member from the Lower Mannville are: Appendicisporites erdtmanii, Aequitriradites variabilis, Rouseisporites reticulatus, Cedripites cretaceus, C. canadensis and Podocarpidites canadensis.

Most of the species listed above under the four groups belong to Cretaceous. The youngest species which probably make their entrance in the Wabiskaw Member are: Appendicisporites trichacanthus var. dissectus and Podocarpidites naumovai n. name listed under group 1c. Both these species make their entrance in Russia during the Albian Stage and indicate a similar

age for the Wabiskaw Member. An early Middle Albian age is indicated for this member on the basis of faunal evidence discussed earlier.

(b) Shale Member

54 species of microspores and pollen, 12 species of marine microplankton and 2 species of megaspores were recorded from the Shale Member. Of the 111 species recorded from the Ellerslie Member, 47 species are present in the Shale Member. 10 species make their "first appearance" within this member, out of which only 3 species have been reported from outside western Canada.

As the Shale Member represents the maximum flooding by the Arctic Sea the microflora is poor. On the other hand, the marine microplankton assemblage is rich and diverse.

The only species indicating an Albian age for this member is Podocarpidites naumovai n. name, which was also recorded from the Wabiskaw Member.

Out of the 12 species of marine microplankton the following 4 species make their "first appearance" in this member.

Baltisphaeridium cf. B. neptuni Eisenack, known range: Aptian of northern Germany.

Veryhachium reductum (Deunff) Jekhowsky, known range: Ordovician to Cenomanian.

Palaeoperidinium granulatum n. sp.

Pseudoceratium gochtii Pocock.

Out of these, the last two species have not been reported from outside

western Canada so far. Canningia colliveri, Hystriosphæridium tubiferum, H. irregulare, Baltisphaeridium sp., B. multispinosum, Pseudoceratium pelliiferum, Odontochitina operculata and Palaeoperidinium cretaceum range into the Shale Member from the Wabiskaw Member.

The microspore "index species" present in the Shale Member are: Appendicisporites tricornitatus, A. crimensis, Trilobosporites apiverrucatus, Aequitriradites spinulosus and Schizosporis reticulatus. These species have wide geographic distribution and are restricted to Cretaceous.

Appendicisporites bifurcatus n. sp. and the megaspore species Minerisporites venustus n. sp. make their entrance in the Shale Member. Appendicisporites perplexus n. sp. becomes abundant in this member. The "index species" restricted to western Canada which persist into the Shale Member from the Lower Mannville are: Appendicisporites erdtmanii, Aequitriradites variabilis, Rouseisporites reticulatus, Cedripites cretaceus, C. canadensis and Podocarpidites canadensis.

The microfloral assemblage recovered from the Shale Member does not provide any significant help in determining its age accurately. An early Middle Albian age is indicated for this member on the basis of faunal evidence discussed earlier.

Grand Rapids Formation

83 species of microspores and pollen, 10 species of marine microplankton and 11 species of megaspores were recovered from the Grand Rapids Formation. Greater portion of the Grand Rapids Formation is brackish with high

representation of marine microplankton. Only the uppermost beds of this formation are deemed to be strictly continental which display a diversity and abundance in microspore, pollen and megaspore representation.

Of the 111 species recorded from the Ellerslie Member 64 species are present in the Grand Rapids Formation. The "index species" Appendicisporites cf. A. pschekhaensis, A. cf. Anemia trichacantha, Cicatricosisporites mediotriatus, Trilobosporites trioreticulosus, Couperisporites complexus, Taurocusporites segmentatus, T. reduncus, Rouseisporites laevigatus, R. triangularis, Verrucosisporites asymmetricus, Arcellites disciformis and many of the long-ranging species which were discontinued in the Shale Member at the height of the boreal flooding, reappear again as soon as the continental conditions are restored in the upper portion of the Grand Rapids Formation.

14 species make their "first appearance" in Grand Rapids Formation, out of which 9 species are known from outside western Canada.

The "index species" of the Grand Rapids Formation can be divided into four groups on the basis of their stratigraphic significance.

Group 1d

Appendicisporites unicus (Markova) n. comb., known range: Cenomanian of Siberia, U.S.S.R.

Arcellites reticulatus (Cookson and Dettmann) n. comb., known range: Albian of South Australia.

Arcellites nudus (Cookson and Dettmann) n. comb., known range: Albian of South Australia.

The 3 "index species" listed above are the youngest and make their entrance in the Grand Rapids Formation. They indicate an Albian age for this formation. A. unicus is very rare in the Grand Rapids Formation. It probably makes its entrance during Albian but does not become abundant till Cenomanian. A Middle Albian age is indicated for the Grand Rapids Formation on the basis of faunal evidence.

Group 2d (Microplankton species)

Baltisphaeridium longispinosum (Eisenack) Eisenack, known range: Ordovician in Europe.

Veryhachium irregulare forma subhexahedron Jekhowsky, known range: Permian and Triassic.

Gonyaulax cf. G. jurassica Deflandre, known range: Oxfordian.

The 3 species of marine microplankton listed above are represented by a single specimen each in the Grand Rapids Formation. They are probably reworked from the sediments of older age. Other species of marine microplankton in Grand Rapids Formation are: Palaeoperidinium cretaceum, Hystrichosphaeridium tubiferum, Baltisphaeridium sp., B. multispinosum, Veryhachium reductum, Palaeoperidinium granulatum and Pseudoceratium pelliiferum. They range upwards into the Grand Rapids Formation from the underlying marine beds. All these species except Veryhachium reductum are restricted to Cretaceous.

Group 3d

Microspore "index species" of the Grand Rapids Formation which are restricted to Cretaceous are: Appendicisporites tricornitatus, A. crimensis,

A. cf. A. pschekhaensis, A. cf. Anemia trichacantha, Cicatricosisporites mediotriatus, Trilobosporites apiverrucatus, T. trioreticulosus, Couperisporites complexus, Taurocusporites segmentatus, Aequitriradites spinulosus, Verrucosisporites asymmetricus, Schizosporis reticulatus and Arcellites disciformis. All these species have wide geographic distribution.

Group 4d

The 'index species' listed under this group have not been reported from outside western Canada so far. Three such species which make their entrance in the Grand Rapids Formation are:

Januasporites spiniferus n. sp.

Leioaletes calvatus n. sp.

Minerisporites macroreticulatus n. sp.

Appendicisporites perplexus n. sp. is abundant in the lower portion of the Grand Rapids Formation, but declines in the upper continental portion. It is absent near the top of this formation. A. bifurcatus n. sp. continues into the Grand Rapids Formation from the Shale Member of Clearwater Formation. Other species in this group which range upwards into the Grand Rapids Formation from the underlying beds are: Appendicisporites erdtmanii, Aequitriradites variabilis, Rouseisporites reticulatus, R. laevigatus, R. triangularis, Cedripites cretaceus, C. canadensis and Podocarpidites canadensis.

Upper Mannville Microflora

The presence of microspore species Appendicisporites trichacanthus var. dissectus, A. unicus, Podocarpidites naumovai n. name, and megaspore

species Arcellites reticulatus and A. nudus within the Upper Mannville microflora indicates that it is probably Albian in age. A more accurate and reliable estimate of the age of the Upper Mannville strata, however, has been made on the basis of ammonite zones. On this basis it is considered to be of Middle Albian age.

The species restricted to the Upper Mannville or younger strata, on the basis of which the Upper Mannville assemblage can be distinguished from the Lower Mannville assemblage are: Appendicisporites trichacanthus var. dissectus, A. cf. Anemia trichacantha, A. unicus, Podocarpidites naumovai n. name, A. perplexus, A. bifurcatus, Januasporites spiniferus, Arcellites reticulatus, A. nudus, Minerisporites macroreticulatus and M. venustus. Besides these, all the 16 species of marine microplankton occur only in the marine facies of the Upper Mannville.

CHAPTER FIVE - PALAEOECOLOGICAL AND PALAEOFLORESTIC INTERPRETATIONS

The pollen frequencies cannot be directly translated into the terms of vegetation because of various variables involved. The different genera have different rates of pollen production. A comparison of modern vegetation with its pollen frequencies preserved in the sediments has been made by Davis and Goodlett (1960, Figure 6) in Vermont, United States. It distinctly shows that vegetational frequencies bear little relation to the pollen frequencies. The genera with a high rate of pollen production have high pollen frequencies although they have low representation in the vegetation. Among the modern plants, through our knowledge of their rate of pollen production, necessary corrections to convert the pollen frequencies into quantitative estimates of the vegetational representation can be made. Such corrections are normally made at the younger Tertiary horizons. However, similar corrections are not possible for the Mesozoic floral assemblages because their precise botanical relationships as well as their rate of pollen production are obscure.

The relationship between the vegetation and its pollen representation in the sediments is distorted by many other factors. Differential destruction of the more delicate type of pollen and spores may be caused in a hot, oxidizing and alkaline environment. The sporopollenin in the exine of the spores takes up oxygen. This auto-oxidized sporopollenin dissolves very easily in an alkaline medium. Therefore, the reducing conditions in bogs may be more conducive to the preservation of the pollen grains than aerobic and microbial conditions in a pond or lake. Moreover, when the pollen grains are transported in water along

with coarse sand a differential destruction of the fragile types occurs due to abrasion. Distortion in the pollen representation is also caused by the difference in their dispersal capacity. Heavier spores and pollen are over-represented in the source area while the more buoyant conifer pollen or the minute angiosperm pollen are disseminated hundreds of miles around the source area by wind and water. In the marine facies of the Upper Mannville the direction of wind, marine currents and the position of estuaries during the time of its deposition must have controlled the quantitative distribution of the pollen and spores in the sediments (Muller, 1959). In the marine deposits, the wind-transported pollen is generally over-represented as compared with the continental deposits. Both the agents of transportation viz. wind and water also lead to size sorting of the pollen and spores, taking the smaller ones farther out and away from their source area. Muller (1959) has shown that there is an increase in the representation of smaller pollen farther out in the sea as compared with the near shore area. The pollen frequencies may also be distorted by the contamination of the younger assemblage by the older due to reworking or by the mixture of two or more ecologic types of pollen grains when pollen belonging to different habitats are introduced by wind or water.

In the present state of our knowledge it does not seem to be possible to arrive at quantitative estimates of floral elements on the basis of pollen frequencies within the Mannville Group. Therefore, only general and broad palaeofloristic and palaeoecological interpretations have been drawn in the present work.

Out of the 72 genera and 161 species described in the present work, 53 genera and 120 species belong to microspores and pollen, 8 genera and 16 species belong to marine microplankton, 10 genera and 23 species belong to megaspores and 2 specimens have been informally described as seeds. The present geographic distribution and habitat of the families and other taxa under which the above genera have been grouped are given in the following list:

Division - Bryophyta.

Family - Sphagnaceae: 1 genus and 2 species were recovered, cosmopolitan, occurs in peat bogs, acid moors and pond margins, indicates a wet lowland terrain.

Division - Pterophyta.

Family - Lycopodiaceae: 2 genera and 6 species were recovered, cosmopolitan, occurs chiefly in the subtropical and tropical forests, but extends into arctic and temperate zones too. It does not occur in arid regions.

Family - Selaginellaceae: 1 genus and 2 species were recorded, cosmopolitan, the majority of the species occur in the tropics in shaded and humid spots.

Family - Osmundaceae: 3 genera and 3 species were recovered, cosmopolitan, mainly temperate and tropical, various species live in shaded and moist woodlands.

Family - Schizaeaceae: 9 genera and 30 species were recorded, mainly tropical and subtropical. Species like Schizaea extend up to Nova Scotia, but also occur north and south of the tropics in America, Australia, Polynesia and New Zealand.

Lygodium occurs in eastern Canada and Anemia is particularly common in tropical America. Both the species occur in tropical to subtropical regions of

both the hemispheres. Mohria occurs only in southeastern Africa. Family Schizaeaceae reached its climax both in diversity and abundance during the Lower Cretaceous. Within the Mannville microfloral assemblage out of 84 species of fern spores, 30 species belong to the family Schizaeaceae.

Bolkhovitina (1959) reports that the family Schizaeaceae originally had 20 genera out of which 16 genera have become extinct and only the four above mentioned genera are living today.

Family - Gleicheniaceae: 1 genus and 2 species were recorded, mainly tropical but also extends into the temperate regions.

Family - Cyatheaceae or Dicksoniaceae: 1 genus and 2 species were found.

Cyatheaceae are mostly tree ferns and are largely confined to the tropics and subtropics, with some forms in temperate regions, especially in the southern hemisphere. They live chiefly in humid forests. The majority of the species in Dicksoniaceae are tropical but a few are also found in temperate regions.

The arborescent species are largely confined to the tropics, but several (species of Dicksonia) are prominent ferns of the warm-temperate southern hemisphere.

Order - Filicales - Incertae Sedis: 18 genera and 39 species of microspores from the Mannville Group were placed under this broad group which has a diverse habitat and world-wide distribution.

Division - Spermatophyta.

Class - Pteridospermae.

Family - Caytoniaceae: Only a single species was recovered. This family apparently became extinct in the Upper Cretaceous.

Class - Gymnospermae.

Order - Cycadales and/or Bennettitales: 2 genera and 6 species were recorded. 3 species probably belong to the family Cycadaceae. This family occurs exclusively in the tropics and subtropics of Mexico, West Indies, Australia, South Africa, East Indies and islands of Indian and Pacific Oceans, at present. They indicate a warm climate. Although at present they usually occur in rocky and arid regions they do not seem necessarily restricted to it. The presence of abundant Nilssonia and Ptilophyllum leaf impressions in the coal-bearing beds all over the world indicates that the cycads were not restricted to the arid zones in the past. It would be erroneous to believe that the presence of the cycads or their fusiform pollen invariably indicates an arid climate. The cycads were very abundant and widespread during the Jurassic and early Cretaceous. However, only 9 genera and 65 species are in existence today.

Order Bennettitales is extinct but probably flourished under similar habitat. 3 species of pollen recorded from the Mannville Group probably belong to this order.

Order - Coniferales: 14 genera and 24 species were recorded. 1 species probably belongs to the family Taxodiaceae. 9 species probably belong to the family Pinaceae. 10 species probably belong to the family Podocarpaceae and 4 species have undetermined affinities. In general, the conifers are distributed widely from subarctic to subtropical regions. From about 40°N and southward, most of them become practically confined to the mountains. However, there is an extensive pine belt running from Gulf coasts to eastern Texas. Pinus occurs mainly in the temperate regions of the northern

hemisphere but extends into subarctic and subtropical zones too. Among the modern species of the family Podocarpaceae, Phyllocladus is restricted at present to New Zealand, Tasmania and New Guinea to Malaysia, Dacrydium has similar distribution but also occurs in Chile and Podocarpus occurs mainly in the temperate regions of the southern hemisphere but also occurs in Cuba, Mexico, central China and southern Japan in the northern hemisphere. In general, most of the conifers either indicate a cool climate or an upland habitat consisting of a moist forest vegetation. Many species of Pinus can grow in warmer climates and their habitat is variable.

Order - Gnetales.

Family - Ephedraceae: 1 genus and 3 species were recovered. Mainly temperate to subtropical. Occurs in scattered patches in hot to very cold, arid, mountainous, rocky or desert regions. This family occurs commonly in New Mexico, Arizona, California, Texas, northern Mexico. Andes regions of Bolivia, Paraguay, Chile and Patagonia, northern Africa, western Alps, France, coasts of Mediterranean and Black Sea, Arabia, Persia, Afghanistan, China and Siberia. Ephedraceae seems to have adapted itself to the extremes of hot and cold climates but it seems to require both climatic and edaphic dryness.

Marine microplankton.

Order - Dinoflagellata.

Family - Peridinidae: 1 genus and 2 species were recovered.

Family - Gonyaulacidae: Only a single species was recovered.

Order - Hystrichosphaeridea.

Family - Hystrichosphaeridae: 3 genera and 9 species were recorded.

Incertae Sedis: 3 genera and 4 species were recorded.

All the 16 species of marine microplankton indicate a brackish to marine environment and are quite abundant in the marine facies of the Upper Mannville in central Alberta.

The botanical relationships of the megaspores are uncertain. Hughes (1955) considers that the elaborate and delicate appendages present on Arcellites indicate an aquatic habit. Cookson and Dettmann (1958) postulated a probable relationship of this genus with Hydropterideae, in particular with the family Marsiliaceae. If this is true, the presence of Arcellites would indicate a flood plain type lowland vegetation containing fairly widespread ponds and shallow lakes.

There are four distinct floral elements present within the Mannville Group:

1. The fern flora consisting of ordinary ferns, tree ferns and water ferns. This flora was probably dominated by the family Schizaeaceae. Associated with these were also present a few species of pteridosperms.
2. The cycad flora belonging to the orders Cycadales and Bennettitales. The presence of Ptilophyllum and Nilssonina in the Grand Rapids Formation indicates that they were probably a part of the Mannville flora and were not introduced from outside. In the opinion of the writer the presence of cycadophytes does not necessarily indicate a dry climate.
3. The conifer flora probably belonging predominantly to the families Pinaceae

and Podocarpaceae. The actual presence of the plants belonging to Coniferales within the Mannville flora is indicated by the occurrence of Pityophyllum, Cyparissidium, Athrotaxites, Pagiophyllum and an abundance of conifer pollen in this group.

4. Ephedralean flora which is represented only by its pollen.

The fern flora indicates a fluvial origin of the Ellerslie Member. The flood plains were covered with the lowland vegetation of ferns, tree ferns, water ferns in the ponds and shallow lakes, and pteridosperms. The cycad and the conifer flora were probably present on a bit more elevated and better drained surface. It is probable that the local variations in topography of the surface supported different vegetative associations. The gymnosperm pollen were partially derived from the locally growing plants and partially introduced from the southwestern upland areas by wind and river water. As mentioned earlier, the "Calcareous" Member is of lacustrine origin, the Clearwater Formation and the lower portion of the Grand Rapids Formation are marine, and the upper coal-bearing portion of the Grand Rapids Formation is probably deltaic in nature. The pollen belonging to Ephedraceae were almost certainly introduced from an outside area with a very arid climate. The pollen production of Ephedraceae is high and is susceptible to long-distance transport by wind. The floral elements of the Mannville Group indicate a warm-temperate to subtropical humid climate.

The pollen studies demonstrate that there is a complete gradation in evolution throughout the Mannville Group. There are no indications of any

major floral breaks within the group. There are no large scale simultaneous appearances of new species or extinctions of the older ones within the Mannville strata.

The Mannville Group in central Alberta completely lacks angiosperm flora. This supports the theory that although a few angiosperms start making their appearance in the Upper Albian Substage, they did not become diversified until the beginning of the Upper Cretaceous.

Comparison of the Mannville Megafloral and Microfloral Records

The Mannville megaflora which was collected from the well cores belonging to the subsurface in central Alberta has been listed earlier. It is only a partial collection from three well cores and by no means represents the whole flora. The following are suggested affiliations for the genera present within the Mannville Group:

Megaflora

Microflora

Division - Pterophyta

Order - Filicales

Sphenopteris spp. ----- Some of the spores placed under
Filicales e.g. Deltoidospora spp.

Family - Schizaeaceae?

Sphenopteris cf. Ruffordia goepperti ----- Cicatricosisporites spp.

Family - Osmundaceae

Cladophlebis spp. ----- Osmundacidites spp., Todisporites spp.

Division - Spermatophyta

Class - ~~Pterid~~ Peridospermae

Order - Caytoniales

Sagenopteris spp. ----- Vitreisporites spp.

Class - Gymnospermae

Order - Cycadales and/or Bennettitales

Ptilophyllum spp. ----- Bennettitaepollenites spp.,
Cycadopites carpentieri

Nilssonia spp. ----- Cycadopites spp.

Order - Coniferales

Family - Pinaceae?

Pityophyllum spp. ----- Pityosporites spp., Alisporites spp.
or other genera allied to Pinaceae.

Family - Araucariaceae?

Pagiophyllum spp. ----- Classopollis spp.

These comparisons refer to only probable botanical relationships.

The writer feels that the megaflora can be related to the microflora with absolute confidence only when the microflora is obtained from the fructifications borne by plants of the megaflora.

CHAPTER SIX - TAXONOMY AND NOMENCLATURE OF FOSSIL SPORES AND POLLEN

The problem concerning the taxonomy and nomenclature of fossil pollen and spores found dispersed in the sediments has been a topic of interesting discussions in the past. Although a complete uniformity in the taxonomic approach is yet to be achieved, during the last few years, there has been a widespread agreement that the names applied to taxa based on fossil spores and pollen are to be governed by the International Code of Botanical Nomenclature. This has been distinctly laid down in Article 7, Note 5 of the International Code of Botanical Nomenclature (Montreal, 1959). It is a definite sign of conformity and order that the demands for an independent system of palynological nomenclature and improvisation of various sorts of trinomial system of nomenclature (Erdtman, 1947, Van der Hammen, 1954) have been discarded. Palynologists all over the world are now working within the framework of the International Code, following the Linnaean system of binomial nomenclature, the usage of natural genera, organ-genera, and form-genera, and the principles of type method and priority.

Most of the present day controversy is not in the field of nomenclature, but in the field of classification of the fossil spores and pollen. The controversy seems to revolve around the main theme as to whether a fossil spore or pollen specimen should be placed under a form-genus, organ-genus or natural genus. The classification of a fossil specimen under any one of these taxa mostly depends upon the individual judgement of a worker concerning the degree of botanical affinity displayed by the specimen. Some workers (Pierce, 1961) who are more concerned with the convenience of use rather than phylogenetic relationships use a purely

morphographic classification and place all their entities under form-genera. Even the "natural" classifications are partly artificial because often the details of ancestry are far from clear. Hence, the taxonomic approach may vary according to the personal philosophy of the worker, the introduction of new concepts of anatomical interpretations or with the special requirements of the classification, but the rules of formal nomenclature as laid down in the International Code of Botanical Nomenclature remain unaffected.

Within the International Code, the following sorts of generic and specific names for the fossil entities are recognized:

Natural genus: It refers to a group of related modern plants and is based upon the sporophytic characters of the complete plant, e.g. Pinus, Populus etc.

International Code of Botanical Nomenclature (Montreal, 1959) defines the rest in following words:

P. 17, Article 3, Note 1. "Since the names of species, and consequently of many higher taxa, of fossil plants are usually based on fragmentary specimens, and since the connection between these specimens can only rarely be proved, organ-genera (organo-genera) and form-genera (forma-genera) are distinguished as taxa within which species may be recognized.

An organ-genus is a genus assignable to a family. A form-genus is a genus unassignable to a family, but it may be referable to a taxon of higher rank (see Art. 59 and Rec. 18 A). Form-genera are artificial in varying degree.

Examples: Organ-genera: Lepidocarpon Scott (Lepidocarpaceae),

Mazocarpon (Scott) Benson (Sigillariaceae), Siltaria Traverse (Fagaceae); form-genera: Dadoxylon Endl. (Coniferopsida), Pecopteris (Brongn.) Sternb. (Pteropsida), Stigmaria Brongn. (Lepidophytales and Lepidospermales), Spermatites Miner (Cormophyta, excl. Eocormophyta et Palaeocormophyta microphylla)."

An organ-genus or-species or a form-genus or-species may include fossils representing several or only parts of natural families, genera or species.

Historical Resume of Systems of Nomenclature and Classification

Ibrahim (1933) classified the Paleozoic spores by combining a morphological prefix with - sporites e.g. Reticulatisporites as a genus for reticulate (Reticulat), trilete (i) spores (sporites). The combining letter for the other spore types was "a" for alete and "o" for monolete spores. This system was widely adopted and genera like Laevigatosporites (monolete) and Punctata-sporites (alete) etc. are still in use.

Raistrick and Simpson (1933), Raistrick (1934, 1935, 1937) and Knox (1938) designated the Paleozoic spores by seven alphabetical symbols variously subdivided with numerical subscripts e.g. C2, C4, F4 etc. Such designations have no formal status and are not valid under the International Code of Botanical Nomenclature.

Wodehouse (1933), while working on Eocene Green River Shale, added the suffix-i pites to the roots of modern family, genus or species names where the relationships were certain e.g. Ericipites, and Pinus strobipites.

Erdtman (1947) proposed a sporotype-sporomorph system under which all the fossil dispersed spores and pollen were placed in morphographic groups.

He felt that even in Tertiary deposits it was not possible to orient fossil pollen and spores in the natural system and therefore devised an artificial classification, which was mainly based on shape groups, aperture type and aperture position, but also attempted to indicate botanical relationships. This system used binomial and often a trinomial system of nomenclature in the manner explained below:

Hexaporites (Nomen typicum abstractum = Sporotype = Genus)

Fagidites (Nomen typicum concretum. Indicates that it is related to Fagus)

Oblatus (Nomen differentiale ÷ Sporomorph = Species)

The name in this case would be expressed as Hexaporites (Fagidites) oblatus and would be referred to as a sporomorph. In those cases where the botanical affinity was not clear, a binomial system of nomenclature was used, and the middle name was dropped.

This system was used by Cookson (1947, 1950) and Ross (1949), with certain modifications. Couper (1953) validated the sporotypes and sporomorphs created by Cookson and Ross, by treating them as genera and species, subjecting them to binomial system and designating a type species. However, both Cookson and Couper continued to use the suffix -ites of Erdtman to indicate organ-genera e.g. Dacrydiumites Cookson, 1953 and Liliacidites Couper, 1953.

In the early 1930's Potonie arranged fossil spores and pollen under the form-genera Sporites and Pollenites. Later on, when family or genus relationships were known the suffix -sporites or -pollenites was added to the family or genus name e.g. Ilex-pollenites iliacus. A question mark was used

where botanic affinity was uncertain e.g. Leguminosae? -pollenites quisqualis. Pollenites or Sporites alone were used where botanic affinity was unknown. However, with time the number and diversity of entities increased to such an extent that the form-genera Sporites and Pollenites were no more adequate to classify them properly.

Potonie, Thomson and Thiergart (1950) revised Erdtman's sporotype-sporomorph system so that several schemes could be used concurrently:

1. Purely artificial morphographic system of form-genera modified from Erdtman's (1947) scheme, for forms of uncertain natural affinity.
2. "Half-natural system" within which a possible botanical affinity could be indicated e.g. Quercoidites an organ-genus of pollen showing similarity to that of Quercus. Later on the endings were modified to -oidae as a suffix added to family roots e.g. Nyssaceoidae, and to -oisporites for spore organ-genus and -oipollenites for pollen organ-genus.
3. "Natural system" included those forms in whose case a positive identification with a natural genus or family was established e.g. Nyssa-pollenites in case it was identical with Nyssa or Nyssaceae-pollenites in case it was considered to belong to family Nyssaceae. The title "natural system" is a misnomer here because as long as any suffix is added the genus could hardly be called "natural".

Under this system quite often a single pollen was listed under three different names e.g. Cicatricosisporites (artificial) Mohriosisporites ("half-natural") and Mohria Typ. (Natural). However, Potonie (1952) made a provision that only artificial names are subject to rules of nomenclature and priority.

In an effort to straighten out the nomenclatural difficulties inherent in the classification discussed above Potonie (1956, 1958a and 1960) brought out three volumes on the genera of dispersed fossil spores and pollen. He has used a purely morphographic system of nomenclature and classification. The groups are as listed below:

Anteturma (Group)	e.g. <u>Sporites</u> H. Potonie, 1893
Turma (Division)	e.g. <u>Monoletes</u> Ibrahim, 1933
Subturma (Sub-division)	e.g. <u>Azonomonoletes</u> Luben, 1935
Infraturma (Suite)	e.g. <u>Psilamonoleti</u> V. d. Hammen, 1955
Form-genus	e.g. <u>Laevigatosporites</u> Ibrahim, 1933

Although Potonie has discussed the botanical relationships of the various form-genera in the above mentioned work, he has not formally placed any of his forms under natural families as organ-genera. His morphographic classification is therefore subject to the provisions of the International Code only at the generic and specific levels.

Potonie and Kremp (1954) made a major contribution to the Paleozoic palynology by subjecting the form-genera belonging to the extinct plant groups of uncertain botanic affinity to the morphographic system of classification discussed above. However, it is felt that among the Mesozoic and Cenozoic pollen and spores where some of the entities can be placed under their natural families a purely morphographic approach would not be suitable. They should be organized by placing the organ-genera under their natural families, and the form-genera under incertae sedis as done by Couper (1953, 1958 and 1960).

Thomson and Pflug (1953), working on Tertiary pollen in east Europe, tried to reduce some of the confusion created through the use of Potonie's dual system (artificial and "half-natural") of classification. They used the morphological groupings of Ibrahim (1933) and the morphological classes of Iversen and Troels-Smith (1950) as a basic framework of classification regardless of affinity. The pollen of Tilia were placed in the form-genus Intratropopollenites of the new class Brevaxones (oblate pollen). In the opinion of the writer such unwieldy names which try in vain to substitute for the morphologic description should be discouraged. Although the authors conceded that if a Tertiary pollen is clearly referable to an extant species, the modern name can be used; and if it is referable only to an extant genus but not to a species, then it should be given a specific epithet and put in a natural genus, they did not use natural genera because of their conviction that in mid-Tertiary or older horizons it is difficult to orient fossil pollen in the natural system. This classification for Tertiary and Cretaceous spores and pollen was followed by Weyland and Krieger (1953), Weyland and Greifeld (1953) and Thiergart (1953). They paid no attention to the rules of priority and the described forms are subject to the International Code only at the generic and specific levels.

Van der Hammen (1954) proposed a morphographic system of classification of fossil spores and pollen based on the terminology proposed by Iversen and Troels-Smith (1950). He based his genera on the number and position of germinal laesurae or pores and species on the exine ornamentation. He used a trinomial system of nomenclature. The natural affinity of pollen and spores,

even in those cases where it was well established, was ignored, and no attention was paid to the rules of priority. This scheme is not valid under the International Code of Botanical Nomenclature.

Pierce (1961) who has used Van der Hammen's scheme after modifying it to a binomial system states: "The satisfaction derived from precision in predicting the proper morphological genus into which a particular specimen will fall can be most fully appreciated when one has witnessed the embittered and confusing arguments of semantic taxonomy." This scheme of classification may be advantageous from the point of view of convenience of use but it has many obvious shortcomings which are listed below:

1. In so far as rules of priority have not been followed, except within the scope of this particular scheme, most of the new genera and species created are invalid under the International Code.
2. As very obscure names are used, it is not possible to compare the assemblage with similar assemblages described from the same horizon in other parts of the world. This reduces the stratigraphic value of the work.
3. The morphologic groupings are too wide. Morphologically distinct forms like Cicatricosisporites and Appendicisporites are lumped under one form-genus Striatriletes (striated trilete spores). This can interfere with a more meaningful zonation of a section.

Naumova (1937), Pant (1954), Norem (1954) and Kuyl et al. (1955) also proposed morphographic systems of classification for fossil pollen and spores.

Traverse (1955) assigned Tertiary spores and pollen inseparable from

a modern genus to that genus. When a spore or pollen was felt to be certainly representative of a modern family, but could not be placed in a known genus within it, fossil or modern, it was referred to a new organ-genus. Organ-genus Horniella, based only on pollen, was created in this manner within the family Rutaceae.

Rouse's (1957) objection: "The main criticism of Traverse's proposal concerns the establishment of new genera within natural families without the provision that the genera and species comprise only fossil spores and pollens", is satisfied by Traverse (1957, p. 258) where he explains clearly that his forms only represent organ-species within a natural genus and organ-genus within a natural family. It is possible to have a few extinct species within a modern genus and a few extinct genera within a modern family in a Tertiary deposit. Traverse used the descriptive terminology of Faegri and Iversen (1950) and Iversen and Troels-Smith (1950).

Rouse (1957) proposed a new nomenclatural system in which he made the following provisions:

1. When a spore or pollen is known to belong within a modern genus, the generic name is used, together with a specific epithet which is composed of a morphologically descriptive root and either of the suffixes -sporites or -pollenites e.g. Gleichenia concavisporites.
2. Where relationships of spores or pollen to modern families are indicated, the genus of that family to which the particular spore or pollen appears to be most closely related is used in combination with either of the -sporites or -pollenites suffixes, e.g. Hymenophyllumsporites trichoma belonging to the family

Hymenophyllaceae.

3. Where no family relationship is suggested morphologically descriptive roots, in combination with the suffixes, form the generic names e.g. Aquilapollenites trialatus.
4. Spores or pollen which are obviously new species of previously established genera are described and incorporated in a conformable fashion within those genera e.g. Deltoidospora rhytisma a new species of genus Deltoidospora as originally proposed by Miner (1935).
5. If spores or pollen are known certainly to be identical with forms which have been previously named, those names are employed. In case where two names have been applied to apparently identical microfossils in the same year, the name indicating a natural relationship is given in preference to an artificial designation.

In the opinion of the writer the last provision is contrary to the rules of priority. Names like Hymenophyllumsporites, even when they indicate natural relationship, cannot have priority over a name for the same genus published earlier but not indicating the natural relationship. However, under Article 58 natural genera have priority over fossil genera under all circumstances.

Potonie (1958b, p. 494) has criticized the first provision of Rouse's nomenclatural approach. He asks a general question: "Whether a spora dispersa should be placed in a genus specially created for spores (organ or form-genus) or in a plant genus of which the genotype is not a spore." Then he gives the answer "... it is not suitable to use for fossil spores and pollen grains, the generic names of recent plants, if we give the spores etc., specific names

whose holotypes are spora dispersae. When a specific name of a fossil spora dispersa is introduced into the genus of a recent plant, the specific name of the spore or pollen grain has no longer any scientific meaning." In short, he wishes to convey that it is against the spirit of type method to put a spore organ-species whose holotype is a spore, within a plant, natural genus whose genotype is a modern plant.

Potonie, however, is not against using modern generic and specific names; he is only against combining a modern generic name of complete plant with a specific epithet representing a fossil organ-species. He has no objection against names like Lycopodium sp., Lycopodium clavatum or Lycopodium cf. clavatum given to spores which are united with their modern plants under the provision of Article 58 of the International Code (Montreal, 1959) which states: "When taxon of recent plants, algae excepted, and a taxon of the same rank of fossil or sub-fossil plants are united, the correct name or epithet of the recent taxon must take precedence." His objection is against expressions like Lycopodium reticulumsporites where Lycopodium represents a modern generic name of a complete living plant and reticulumsporites is a specific epithet representing a fossil-organ species.

Pocock (in press) states: "Spores and pollen can only be regarded as parts (organs) of plants when considered with relation to the natural system. It is, therefore, wrong to assign a species of dispersed spores to a natural genus." He insists that the spores of Anemia colwellensis should be referred to as spores of A.colwellensis, because the spores themselves are not

A.colwellensis.

There is no doubt that the provision for naming of combined taxa in the International Code of Botanical Nomenclature (Montreal, 1959) is not very clear. Faegri (1963) has commented on it in detail. Rec. 57 B of the Code states: "Fossil specimens uniting diagnostic features of diverse taxa may be either assigned to one of them, thereby enlarging its circumscription, or proposed as a new taxon having the amplified circumscription (but see Art. 63)." This permits the names like Calymmatotheca to mean both the whole plant as well as only a cupula. If this name were restricted to the plant alone after reconstruction how shall we refer to cupula? The provision to use the name of one of the constituent taxa when naming combined taxa is certainly confusing, and should be dropped; only the later provision of naming it as a new taxon should be retained. Names created under the later provision are precise and helpful in referring to individual organs, as well as the combined unit separately e.g. Walchia (foliage), Walchiostrobus (seed cone), Carpolithus (seed) and Pollenites (pollen) were all combined under genus Lebachia. The same should be applicable when fossil plant fragments are united with modern plant under Article 58. When a fossil leaf, stem, root, inflorescence, seed and pollen are united under a recent plant e.g. Fagus we should retain the original name if they have already been named or refer to them as seed, pollen, inflorescence etc. of Fagus. Fagus itself, like Lebachia, denotes a combination of related organs, which in this case is represented by the total sporophytic character of the nomenclatural type of Fagus, which is a complete plant.

On the other hand, it has been a common practice to place organ-species representing fossil leaves etc. under natural genera; and the zoologists who had no choice because they have no provision for organ-genera and form-genera have done the same with vertebrate bones etc. This practice has been extended to the fossil pollen and spores by Bolkhovitina (1953, 1956, 1961), Rouse (1957, 1959), Traverse (1955), Couper (1953, 1960) and some others. However, the opinion is divided on the question of using natural genera all over the world. A recent conference of the Russian palynologists (Bolkhovitina et al. 1962) could not bring about a unanimity of opinion on this problem.

A more serious difficulty, however, in the assignment of a fossil spore or pollen to its natural genus, is the determination of its botanical affinities very accurately. If a spore is placed in such a genus the author should be able to say which species of the genus it most resembles and why it should not be placed in another genus. In spite of all this, the determination of the degree of botanical affinity shown by a specimen shall remain a matter of individual judgement. What one worker may feel inclined to place within a natural genus, the other worker may decide to place within an extant family as an organ-genus. Typical of such controversies is Hughes' (1961, p.295) objections against the use of the natural genus Ephedra in Mesozoic times. He states: "Palynological evidence of the widespread existence of plants similar to the Chlamydospermales in Mesozoic times is accumulating; no progress has yet been made, however, with macrofossil identification of the group. In this connexion I regret the placing of fossil pollen species in extant genera such as

Ephedra (Scott 1960), which is likely to be a hindrance to understanding, if not actually contrary to the Rules of Nomenclature (Potonie 1960, p. 21). If there was a Mesozoic group at all, it is unlikely that its members will prove to be close in affinity to the three surviving relict genera; as has been shown many times with other groups, the evidence of a single organ is quite insufficient."

Similar objections can be raised against placing of the fossil schizaeaceous spores within the four surviving genera viz. Schizaea, Anemia, Mohria and Lygodium. It is an accepted fact that family Schizaeaceae reached its climax in Lower Cretaceous. Bolkhovitina (1959) refers to the sixteen genera which have become extinct since then. There may have been more which have not been detected yet. It does appear a bit strange that in most cases only the four above mentioned surviving genera have been used to accommodate the fossil schizaeaceous spores and the remaining extinct genera have been only rarely used. It has been shown that there is so much overlap in characters between the spores of Anemia and Mohria that it is very difficult to distinguish them. Similar extinct genera with overlapping characters from Mesozoic times would be impossible to distinguish from the living genera. It is quite possible that many of the forms that have actually been referred to the four surviving genera of family Schizaeaceae actually belong to such extinct genera with overlapping morphological characters. Rouse (1957, pp. 351-352) states: "It has not been shown to date that gametophytic characters alone are diagnostic of families or even genera. Contrastingly, it is known that in several natural families, e.g. Polypodiaceae, the spores are not definitive." In the opinion of the writer the value of a name can be no

greater than the accuracy with which the botanical relationships of a fossil spore or pollen are determined. If a genus like Anemia is extended back, it must be done step by step all the way in quite small stratigraphic units, and on each occasion there must be enough evidence to redescribe and re-circumscribe the taxon.

The principle of priority must always prevail. However, in case of the names of fossil spores and pollen using natural genera, the question of priority is linked with and is entirely due to the fact that the fossil pollen and spores were placed within the living natural genera. The question of priority in these cases, therefore, also entails the acceptance of the interpretation of botanical affinity arrived at by a certain author. In so far as the interpretation of such botanical affinities are very much dependent on individual judgement, the question of priority shall remain subject to it. The onus of proof that a fossil spore or pollen belongs to a natural genus and not to an extinct or living genus with overlapping morphological characters primarily lies with the original author.

Taxonomic Approach Adopted for Spores and Pollen of the Mannville Group

As a result of the above considerations and the fact that the present state of knowledge concerning the natural relationships of the fossil plant groups at a horizon as old as Lower Cretaceous is far from sufficient a systematic approach similar to that of Couper (1958) has been adopted in this work. It is noteworthy that Couper who has used names of natural genera (Couper, 1953 and 1960) for Tertiary spores and pollen did not consider it suitable to use the same

for the Jurassic and Lower Cretaceous spores and pollen from England. The salient features of the present taxonomic approach are as follows:

1. Potonie's (1956, 1958a and 1960) systematic account has been used at the generic and specific levels only.
2. Only form-genera and organ-genera have been used. Organ-genera have been assigned to their respective natural families.
3. Wherever possible the botanical affinity has been discussed.
4. The forms which have been assigned to natural genera on previous occasions by the authors who are in favour of using natural genera for Mesozoic spores and pollen, have their natural generic names listed under the heading of remarks to facilitate comparative study with other microfloral assemblages.
5. The principles of priority and type method have been followed.

CHAPTER SEVEN - PREPARATION TECHNIQUE

Most of the samples were organic-rich shales and siltstones. A preparation technique particularly suited to this type of sediment was therefore adopted. The basic steps in the maceration process were as given below:

Note: After each step of chemical treatment, the material was centrifuged and washed in distilled water until it was neutral.

Step 1.

In order to avoid the risk of contamination, the material for processing was taken from the inner portion of the core. About 10 to 15 grams of material taken in this manner was thoroughly washed with distilled water, dried, and then crushed to a grain size of about 1 to 4 mm. This material was placed in 250 cc. polyethylene bottle. Linear polyethylene was found to be adequately heat resistant and did not crack or buckle, in spite of the high degree of heat generated in various reactions. The calcareous samples were treated with phosphoric acid (ortho 85% H_3PO_4) which was diluted about 50% with distilled water. The length of time required is dependent upon the calcareous content of the individual samples.

Step 2.

The digestion of the mineral matter and silica cement was carried out by covering the sample with hydrofluoric acid (48% HF). The hydrofluoric acid used for this purpose was at least three times the volume of the sample. In the first few minutes sufficient reaction heat was generated which volatilized most of the silicon as SiF_4 . The sample was digested for about 24 hours with

periodic stirring. After this the sample was washed in distilled water and short-centrifuged (a centrifuge run of 45 seconds at about 1500 r.p.m. followed by decanting) to get rid of hydrofluoric acid and clay particles.

Step 3.

The sample was then oxidized in freshly made Schultze's solution (one part saturated aqueous solution of potassium chlorate (KClO_3) with two or three parts of cold nitric acid (70% HNO_3). The length of time needed for oxidation varies with the individual samples. The amount of natural oxidation suffered by the organic material during and after accumulation of the sediments is an important factor in determining the length of oxidation time. Usually the sample was oxidized till the blackish organic material just started turning brown. This took from 10 to 20 minutes in the case of shale samples and 2 to 3 hours in the case of shaly coal. At this stage it is better to leave the sample slightly under-oxidized. Oxidation was followed by short centrifuging to get rid of the clay particles.

Step 4.

For solubilizing the humic and superfluous organic material thus oxidized, the sample was suspended in potassium carbonate (5% K_2CO_3) solution for three to five minutes. As the humic material dissolved in potassium carbonate the liquid turned dark brown. The sample was never kept in potassium carbonate for a period longer than five minutes and was immediately diluted with distilled water as soon as the liquid had turned dark brown. Potassium carbonate can dissolve the more fragile spores if care is not exercised at this stage.

This was followed by washing in distilled water and short centrifuging to get rid of the dissolved humic material and to remove the clay particles. The washing and centrifuging was continued till the liquid was comparatively clear and most of the clay was removed.

Step 5.

The sample was then wet sieved through a 100 mesh (.149 mm. or 149 microns) sieve. The material left on the sieve was transferred to water in a petri dish and searched for megaspores under a Zeiss Opton binocular microscope at a magnification of approximately 16 diameters. The megaspores which were too opaque for examination in transmitted light were cleared by treating with concentrated nitric acid (70% HNO_3). The translucent specimens were mounted in corn syrup (three parts of corn syrup (d - glucose), and two parts of distilled water in which several crystals of phenol had been dissolved). Opaque megaspores were mounted dry in well slides.

Step 6.

The portion of the sample that passed through the 100 mesh sieve (less than 149 microns) was then suspended in heavy liquid zinc bromide (ZnBr_2) solution in water with a specific gravity of 2 (2000 grams of ZnBr_2 dissolved in 1000 cc. distilled water and acidified by a trace of HCl) in two glass test tubes and centrifuged. The inorganic material, being heavier, collected at the bottom of the test tube and the lighter organic residue collected at the top. This organic residue was collected by the help of a fine spatula and a dropper and was placed in distilled water in a bottle. The heavy liquid separation was repeated twice to

avoid any loss of pollen and spores which could be caught in between the settling particles of the inorganic material. At this stage the organic residue was examined under microscope and if there was too much superfluous organic material, it was reoxidized (step 3) and resolubilized in potassium carbonate (step 4). The organic residue thus separated was thoroughly washed in distilled water and then preserved in glycerine in a small test tube.

Step 7.

Corn syrup was used as a mounting medium. A minute part of the organic residue was placed at one end of a standard microscope slide and covered with one or two drops of corn syrup. The mass was then mixed with a scalpel and spread evenly and thinly down the length and width of the slide. Every time a new slide was made the organic residue preserved in the test tube was thoroughly stirred and mixed.

A few slides were also prepared in polyvinyl alcohol (Elvanol Grade 51-05). Some Elvanol was dissolved in moderately heated water and a solution of the viscosity of glycerine was prepared. The solution was filtered to remove any undissolved solid particles. A minute part of the organic residue was placed on a cover slip and covered with a drop of Elvanol solution. The mass was then spread out evenly and thinly all over the cover slip. The smear thus made was dried on a hot plate. A drop of canada balsam dissolved in Xylol was placed on a standard microscope slide and the cover slip was placed on it with the organic smear facing downward. The slides were dried slowly at low temperatures for a few days, because at a high temperature the moisture present in the mounting

medium is converted into steam and bubbles appear below the cover slip.

It is felt that corn syrup is good as a mounting medium for examining samples because the specimens can be moved and re-oriented for thorough examination, but for the permanent preservation of types Elvanol is definitely superior as a mounting medium. The shortcoming of corn syrup is that it always remains somewhat tacky and the types may be easily lost if the slides are handled carelessly.

Photomicrography

Photomicrographs were taken on a Carl Zeiss Photomicroscope Pol. 35 mm. Adox KB 14 negative film was used and the photographs were printed on Kodak Polycontrast F single weight paper. Polycontrast filters were used to produce sufficient contrast on the prints. A blue filter was normally used while taking photographs, but in the case of very dark and opaque spores a dark red filter was used. Some oil immersion photomicrographs were taken at a high magnification by Carl Zeiss Plan 100/1.25 oel. 160/ - objective.

All the specimens were illustrated on the final plates at a magnification of x 500 to give an idea of the relative size difference. The higher magnifications are at x 1024, x 1575, 1967 and x 2500.

Sampling Procedure

In order to get a representative sample of the whole core at least one piece of shale or siltstone was collected at a depth interval of every three feet. Three such samples were then mixed together as one sample to represent a depth interval of 9 or 10 feet. Imperial Namao No. 1 well and Imperial Willingdon No. 1

well had long and irregular core lengths, therefore, it was not possible to restrict the samples within individual core lengths. In these wells samples usually represent a depth interval of 10 feet and are composed of one or more pieces of shale or siltstone collected from a depth of every 3 feet and 4 inches to make the sample representative. In some cases, where more detailed study has been made in thick organic shale intervals individual samples may represent only 2 feet and 6 inches of core. In other cases where shale or siltstone partings were present in narrow zones between coarse sand intervals (which were not sampled) the samples may represent less than 10 feet of core. In Fort Augustus No. 1 well the individual core length is usually 9 feet, therefore the samples were restricted within individual core lengths. The samples in this case mostly represent a depth interval of 9 feet and are composed of one or more pieces of shale or siltstone collected from a depth of every 3 feet to make the sample representative. Even in the sandy portions of the core there were enough shale or siltstone partings from which samples have been collected.

Examination of the Microscope Slides

About three slides per sample were examined by traversing each slide lengthwise along lines separated by a distance of 5 mm. at a magnification of x 125. As the examination of the slide progressed, identifiable and well preserved specimens of various species were counted and recorded as abundant (10 or more specimens), common (5 to 9 specimens), rare (2 to 4 specimens) or single (1 specimen). No further counting was done for those species which once exceeded 10 specimens in a sample. In this manner a rough estimate of relative

frequency of each species in each sample was made. Later on the same slides were searched under low power (x 31.25) for rarer specimens. Besides these three slides usually one or two more slides from the same sample were searched under low power for rarer specimens.

Designation and Preservation of Types

Microscope slides were prepared with a mounting medium of corn syrup. Most of the holotypes have been preserved as single spore or pollen slides, the rest which were too small or too fragile to be removed have been left on the composite slides. Holotypes on the single spore or pollen slides have been designated as follows:

First the serial number of the slide is given preceded either by Micro (microspore or marine microplankton) or Mega (megaspore) e.g. Micro. 140.

This is followed by the code of the type locality:

IN = (Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.)),

FA = (Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R.21, W. 4th Mer.)) or

IW = (Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.));

followed by the depth interval from which the sample was obtained e.g. IN 3716-3726.

This is followed by the stage co-ordinates, The "vertical reading" is given first and the "horizontal reading" next e.g. 3/36. The name of the species is given on each slide.

To facilitate the location of the holotype, a small red or blue waterproof ink dot has been placed close to the specimen. In this manner it can be easily located without using the co-ordinates.

Holotypes on the composite slides have been designated as follows:

The slide number consists of the code of the type locality followed by the depth interval, and the number of slide for the sample from that depth interval. In many cases more than five slides were made from one sample. A slide number indicating FA 2842-2851-4 means that the type locality is Fort Augustus No. 1 well, the sample was taken between the depths of 2842 and 2851 feet and is the 4th slide of that sample. No serial number is given to the slide in this case. In all other respects the designation of the holotype on composite slide is the same as in the case of the single spore or pollen slide.

All holotypes, composite and single spore and pollen slides, processed residues and unprocessed portions of the samples are deposited in the permanent collection of Paleobotany Section, Research Council of Alberta, Edmonton, Alberta, Canada.

CHAPTER EIGHT - SUMMARY AND CONCLUSIONS

The Mannville Group in central Alberta includes all the Lower Cretaceous rocks deposited before the gulfian flooding as well as the St. Edouard Member in east-central Alberta. The brackish to marine middle portion of the Mannville has yielded a datable microfauna of foraminifera belonging to the Middle Albian Substage, but the age of the fresh-water pelecypods and ostracodes found in the continental Lower Mannville has been in long dispute. The principal objectives of this palynological study were to ascertain the age of the continental Lower Mannville and to establish the microfloral sequence within the Mannville Group.

Many of the stratigraphically significant species belonging to the Mannville microflora also occur in northwestern Europe, Russia and Australia. The association of Arcellites disciformis Miner (? = Pyrobolospira hexapartita Hughes) with Dijkstraisporites helios (Dijkstra) Potonie and the presence of Trilobosporites hannonicus (Delcourt and Sprumont) Potonie, Pilosporites verus Delcourt and Sprumont and Couperisporites complexus (Couper) Pocock within the Deville and Ellerslie Members, indicates that these members represent the upper Wealden Arcellites (Pyrobolospira) flora of Barremian and lowermost Aptian age (Hughes, 1958). Cicatricosisporites perforatus (Baranov et al.) n. comb. and Trilobosporites trioreticulosus Cookson and Dettmann which have so far not been reported from horizons older than Aptian, make their entrance in the Ellerslie Member. This confirms an approximately Barremian-Aptian age for this member. No stratigraphically significant species make their entrance in the "Calcareous"

Member. However, the intercalation of the early Middle Albian foraminifera and marine ostracodes with the fresh-water ostracodes of the "Calcareous" Member indicates an early Middle Albian age for these beds (Mellon and Wall, 1961).

The Middle Albian boreal flooding resulted in a distinct decline in both, the abundance as well as the variety of the microflora but the marine microplankton assemblage is rich and diverse in the brackish and marine facies of the Upper Mannville. The marine microplankton occur down to the unconformable contact of the Cretaceous section with the Palaeozoic carbonates in the Imperial Willingdon No. 1 well, which is situated on the western flank of the Wainwright Ridge. This indicates that the continental Lower Mannville is missing by non-deposition in this well. It appears that the Wainwright Ridge remained exposed until it was inundated by the boreal flooding.

The youngest species which make their entrance in the Wabiskaw Member are Appendicisporites trichacanthus (Maljavkina) var. dissectus (Markova) n. comb. and Podocarpidites naumovai n. name (= Podocarpus major (Naumova) Bolkhovitina). Both these species make their entrance in Russia during the Albian Stage and indicate a similar age for the Wabiskaw Member. No stratigraphically significant species make their entrance in the Shale Member of the Clearwater Formation. However, this member has been accurately dated as early Middle Albian in age on the basis of the association of its foraminiferal assemblage with the ammonite Subarcthoplites mcconnelli (Whiteaves) of early Middle Albian age, in the outcrops of Clearwater and Loon River shales in the northern Alberta. Appendicisporites unicus (Markova) n. comb., Arcellites reticulatus (Cookson

and Dettmann) n. comb. and A. nudus (Cookson and Dettmann) n. comb. make their entrance in the Grand Rapids Formation. These species have so far not been reported from horizons older than Albian and indicate a similar age for this formation. Many long-ranging species which were discontinued in the Shale Member of the Clearwater Formation at the height of the boreal flooding, reappear again as soon as the continental conditions are restored in the upper portion of the Grand Rapids Formation.

Many species in the Mannville microflora have only local distribution. Some of these species have a restricted range and are useful for local correlations. The most important among such species are: Appendicisporites jansonii Pocock, Trilobosporites canadensis Pocock, Concavissimisporites parkinii (Pocock) n. comb., Cooksonites variabilis Pocock, Cooksonites reticulatus Pocock and Arcellites rugosus n. sp. which make their appearance in the Deville Member and seem to be restricted to the Lower Mannville strata. Hymenozonotriletes mesozoicus Pocock which makes its entrance in the Ellerslie Member is also restricted to the Lower Mannville. Appendicisporites perplexus n. sp. appears in the Wabiskaw Member, and becomes abundant in the Shale Member of the Clearwater Formation and the marine lower portion of the Grand Rapids Formation. This species is absent from the upper continental portion of the Grand Rapids Formation. Januasporites spiniferus n. sp. and Minerisporites macroreticulatus n. sp. make their entrance in the Grand Rapids Formation.

The pollen studies show that there is a complete gradation in evolution throughout the Mannville Group. There are no indications of any major floral breaks

within the group.

The Mannville Group in central Alberta lacks angiosperm flora. The described species of microspores and pollen include 1 genus and 2 species of Sphagnaceae, 2 genera and 6 species of Lycopodiaceae, 1 genus and 2 species of Selaginellaceae, 3 genera and 3 species of Osmundaceae, 9 genera and 30 species of Schizaeaceae, 1 genus and 2 species of Gleicheniaceae, 1 genus and 2 species of Cyatheaceae or Dicksoniaceae, 18 genera and 39 species belonging to Filicales - Incertae Sedis, 1 genus and 1 species of Caytoniaceae, 2 genera and 6 species belonging to Cycadales and/or Bennettitales, 14 genera and 24 species belonging to Coniferales and 1 genus and 3 species of Ephedraceae. The marine microplankton assemblage includes 1 genus and 2 species of Peridinidae, 1 genus and 1 species of Gonyaulacidae, 3 genera and 9 species of Hystrichosphaeridae. 3 genera and 4 species of the marine microplankton have been placed in Incertae Sedis. The botanical relationship of the 10 genera and 23 species belonging to the megaspores is uncertain.

On the basis of the above flora it is interpreted that during the deposition of the continental Lower Mannville, the flood plains of the Edmonton Channel and other drainage channels were probably covered with the lowland vegetation of ferns and pteridosperms. The cycad and conifer flora were probably present on a bit more elevated and better drained surfaces. The ephedralean pollen were introduced in the Mannville microflora from an arid habitat and were not derived from the regional flora. The marine microplankton were introduced in the Upper Mannville strata during the Middle Albian boreal flooding. The

palaeoecological study indicates a continental origin for the Lower Mannville, followed by a brackish and marine environment in the Upper Mannville, with a return to fresh-water conditions close to the top. The floral elements of the Mannville Group suggest a warm-temperate to subtropical humid climate.

Tentative suggestions concerning the probable botanical relationships between the megafloora and the microflora have also been made, which indicate that all the genera of the Mannville megafloora are probably represented in the spore and pollen assemblage of these beds.

The generic categories within which the spores and pollen are classified are essentially those outlined by Potonie (1956, 1958a and 1960). A systematic approach of placing these genera within natural families or orders, similar to that of Couper (1958) has been followed.

CHAPTER NINE - SYSTEMATIC DESCRIPTIONS

FAMILY SPHAGNACEAE

Genus Sphagnumsporites Raatz, 1937

- 1934 Sporites stereoides Potonie and Venitz, Arb. Inst. Palaeob. Petr. Brennsteine 5, p. 11, pl. 1, fig. 4.
- 1937 Sphagnumsporites Raatz, Abh. Preuss. Geol. L. A. Berlin, 183, p. 9.
- 1953 Stereisporites Pflug, Palaeontographica B, 94, p. 53.
- 1953 Sphagnites Cookson, Aust. J. Bot. 1(3), p. 463, pl. 1, figs. 1-4.
- 1956 Sphagnumsporites stereoides (Potonie and Venitz) Potonie, Beih. Geol. Jb. 23, p. 17, (type species).

DIAGNOSIS: Trilete; laesurae simple, may or may not reach the equator;

size small; equatorial outline triangular with convex sides; corners rounded,

sometimes arched; exine smooth, relatively thick and rigid.

Sphagnumsporites antiquasporites (Wilson and Webster) Pocock, 1962

Plate 1, figure 1

- 1946 Sphagnum antiquasporites Wilson and Webster, Am. J. Bot. 33(4), pp. 271-278.
- 1947 Trilites australis Cookson, B.A.N.Z. Antarct. Research Exped., Rept. A 2(8), p. 136, pl. 15, figs. 58-59.
- 1953 Sphagnites australis Cookson, Aust. J. Bot. 1, p. 463, pl. 1, figs. 1-4.
- 1959 Sphagnum punctaesporites Rouse, Micropaleo. 5(3), p. 308, pl. 1, figs. 25-26.
- 1962 Sphagnumsporites antiquasporites (Wilson and Webster) Pocock, Paleontographica B, 111, 1-3, p. 32, pl. 1, figs. 1-3.

DESCRIPTION: Trilete; laesurae simple, from 1/2 to 2/3 of radius of spore;

equatorial outline triangular with strongly convex sides; corners rounded; arcuate

thickenings subtend the angles of the laesurae; 1 micron wide thickened zone around

the equator; exine smooth.

SIZE RANGE: Equatorial diameter 20 to 28 microns.

DISTRIBUTION: Upper Jurassic, Cretaceous and Tertiary. Abundant.

AFFINITY: In morphology, this spore is similar to the spores of recent species of Sphagnum.

REMARKS: Under a taxonomic approach which favours the use of natural genera these specimens would be placed under Sphagnum antiquasporites.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well
(Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
Pl. 1, fig. 1. Depth 1781 to 1791 feet; Grand Rapids Formation.
REPOSITORY: Res. Coun. Alberta Palynological Type Coll.
Pl. 1, fig. 1. Slide No. Micro. 110; co-ord. 14.4/37.5.

Sphagnumsporites psilatus (Ross) Couper, 1958

Plate 1, figure 2

- 1949 Trilites psilatus Ross, Bull. Geol. Inst. Upsala 34, p. 32, pl. 1, fig. 12.
1958 Sphagnumsporites psilatus (Ross) Couper, Palaeontographica B, 103,
p. 131, pl. 15, figs. 1-2.

DESCRIPTION: Trilete; laesurae simple, about 1/2 the radius of spore; equatorial outline triangular with strongly convex sides; corners rounded; arcuate thickenings subtend the angles of the laesurae; 3 microns wide thickened zone around the equator; exine moderately verrucose.

SIZE RANGE: Equatorial diameter 30 to 33 microns.

DISTRIBUTION: Jurassic and Cretaceous. Rare.

REMARKS: This species differs from Sphagnumsporites antiquasporites in its larger size, verrucose exine and wider equatorial thickening.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well

(Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 1, fig. 2. Depth 1921 to 1931 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 1, fig. 2. Slide No. IW1921-1931-1; co-ord. 18/65.6.

FAMILY LYCOPODIACEAE

Genus Lycopodiumsporites Thiergart ex Delcourt and Sprumont, 1955

1934 Sporites agathoecus Potonie, Arb. Inst. Palaeob. Petr. Brennecke 4, p. 43, pl. 1, fig. 25.

1938 Lycopodiumsporites agathoecus (Potonie) Thiergart, Jb. Preuss. Geol. L.-A. (1937) Berlin, 58, p. 293, pl. 22, figs. 9-10, (type species).

DIAGNOSIS: Trilete; equatorial outline subtriangular; laesurae may reach equator; distal surface reticulate with regular muri; muri are sometimes high; proximal surface unsculptured.

Lycopodiumsporites austroclavatidites (Cookson) Pocock, 1962

Plate 1, figures 3, 4

1953 Lycopodium austroclavatidites Cookson, Aust. J. Bot. 1, p. 469, pl. 2, fig. 35.

1953 Lycopodium sp. (fastigiatum-volubile group) Couper, N. Z. Geol. Surv. Pal. Bull. 22, p. 19, pl. 1, fig. 2.

1958 Lycopodiumsporites clavatoides Couper, Palaeontographica B, 103, p. 132, pl. 15, figs. 10-13.

1959 Lycopodium reticulumsporites Rouse, Micropaleo. 5(3), p. 309, pl. 2, figs. 1-3.

1962 Lycopodiumsporites austroclavatidites (Cookson) Pocock, Palaeontographica B, 111, pl. 1, figs. 5-6.

DESCRIPTION: Trilete; laesurae distinct, about 3/4 of radius of spore; equatorial outline rounded-triangular; contact area of proximal face unornamented; distal surface and remainder of proximal face reticulate, lumen of reticulum 7 to

12 microns across; muri 1 micron thick project up to 4 microns.

SIZE RANGE: Equatorial diameter 30 to 40 microns.

DISTRIBUTION: Jurassic and Lower Cretaceous. Common.

REMARKS: The genus Lycopodiumsporites was validated in 1955 when a "lectogenotype", L. agathoecus (Potonie) Thiergart, 1938 was selected by Delcourt and Sprumont (1955, p. 31).

LOCALITY OF FIGURED SPECIMENS: Imperial Willingdon No. 1 well Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 1, fig. 3. Depth 1781 to 1791 feet; Grand Rapids Formation.

Pl. 1, fig. 4. Depth 1791 to 1801 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 1, fig. 3. Slide No. Micro. 96; co-ord. 9.9/38.1.

Pl. 1, fig. 4. Slide No. IW1791-1801-1; co-ord. 5.9/66.

Lycopodiumsporites cerniidites (Ross) Delcourt and Sprumont, 1955

Plate 1, figures 5, 6

1949 Lycopodium cerniidites Ross, Bull. Geol. Inst. Upsala, 34, p. 30, pl. 1, figs. 1, 2.

1955 Lycopodiumsporites cerniidites (Ross) Delcourt and Sprumont, Mem. Soc. Belg. Geol., n.s. 4(5), p. 32.

DESCRIPTION: Trilete; laesurae over 3/4 of radius of spore; commissures surrounded by a distinct margo; equatorial outline rounded triangular; proximal face flat and smooth; distal face convex, ornamented by irregularly anastomosing low rugulae; exine thick.

SIZE RANGE: Equatorial diameter 30 to 50 microns.

DISTRIBUTION: Jurassic and Cretaceous. Rare. Reported from the upper part of the Vanguard Formation (Pocock, 1962) to the Grand Rapids Formation in western Canada. Originally reported from the Santonian Stage of Sweden (Ross, 1949).

AFFINITY: This species has a close resemblance to the recent spores of Lycopodium cernuum.

REMARKS: The spores described above are larger than those originally described by Ross, which had a size range between 24 and 29 microns. In all other respects they are identical.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 1, fig. 5. Depth 2442 to 2451 feet; Grand Rapids Formation.

Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 1, fig. 6. Depth 1921 to 1931 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 1, fig. 5. Slide No. 169; co-ord. 11.8/40.8.

Pl. 1, fig. 6. Slide No. 150; co-ord. 11/36.2.

Lycopodiumsporites marginatus n. sp.

Plate 1, figures 7 - 10

DESCRIPTION: Trilete; laesurae extending up to 3/4 of the spore radius; commissures raised, about 3 microns wide; equatorial outline triangular with strongly convex sides; proximal surface smooth with a few irregular ridges; distal surface convex, reticulate with polygonal muri; reticulum very broad ranging from 9 to 14 microns in diameter; muri only 1 micron wide and raised into a membraneous network about 10 microns high, muri thickened and appear rod-like where they intersect.

SIZE RANGE: Equatorial diameter (including the membraneous zone) 50 to 60 microns.

Equatorial diameter of the holotype 60 microns.

DISTRIBUTION: Barremian? to Middle Albian. Rare. In central Alberta this species is more common in the Lower Mannville becoming rare in the Upper Mannville

strata.

REMARKS: Lycopodiumsporites marginatus resembles Woodsia reticulata (= Hymenozonotriletes reticulatus) Bolkhovitina, 1953. However, Woodsia reticulata can be distinguished by its larger size (65 to 70 microns), broader muri, laesurae which extend up to the equator, and larger lumina (20 to 25 microns).

TYPE LOCALITY: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Holotype: Pl. 1, figs. 8 - 10. Depth 3084 to 3093 feet; Ellerslie Member.
Pl. 1, fig. 7. Depth 3028 to 3037 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 1, figs. 8 - 10. Slide No. FA 3084-3093-4; co-ord. 0.5/37.
Pl. 1, fig. 7. Slide No. FA 3028-3037-2; co-ord. 5/31.

Lycopodiumsporites sp. A

Plate 1, figure 11

DESCRIPTION: Trilete; commissures raised with 5 microns wide thickened lips; laesurae reaching the equator; equatorial outline triangular; sides straight to slightly convex; proximal surface smooth; distal surface reticulate with polygonal muri; reticulum 8 to 10 microns in diameter; muri 3.5 microns wide and 3 to 4 microns high.

SIZE RANGE: Equatorial diameter about 48 microns.

DISTRIBUTION: Barremian? to Middle Albian. Very rare. A few specimens of this species were recorded from the Ellerslie Member and the uppermost portion of the Grand Rapids Formation.

REMARKS: This species has not been formally described as very few specimens assignable to it were found. Thus it was not possible to determine the range of

variation within the species.

The thick muri make this spore similar to forms in the genus Dictyotriletes. However, the polygonal and raised muri of the distal reticulate surface on this species are characteristic of the genus Lycopodiumsporites rather than Dictyotriletes which has a low, flat, and rounded foveo-reticulate pattern.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 1, fig. 11. Depth 1781 to 1791 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 1, fig. 11. Slide No. Micro. 98; co-ord. 13.1/39.3.

Genus Lycospora Schopf, Wilson and Bentall, 1944

1940 Cirratiradites micropapillatus Wilson and Coe, Am. Mid. Nat. 23 (1), p. 184, fig. 6.

1944 Lycospora micropapillatus (Wilson and Coe) Schopf, Wilson and Bentall, Illinois Geol. Surv. Report of Investigations 91, p. 54, pl. 3, figs. 19-19b, (type species).

DIAGNOSIS: Trilete; trilete mark distinct and simple, extends almost to the margin; cingulate; equatorial outline nearly circular to sub-triangular; central body laevigate, infragranulate or granulate.

Lycospora sp.

Plate 1, figures 12 - 15

DESCRIPTION: Trilete; laesurae simple slits, extending almost up to the margin of the central body, equatorial outline rounded - triangular; proximal surface granulate, distal surface verrucate, verrucae often anastomosing with irregular outline, they are so closely packed that at low focus they look like narrow irregular lumina,

distal face strongly convex, cingulum present but only slightly thicker than the body wall.

SIZE RANGE: Equatorial diameter 30 microns.

DISTRIBUTION: Middle Albian. Very rare. In central Alberta a single specimen of this species was recorded from the Wabiskaw Member.

REMARKS: This species has not been formally described as only one specimen was found.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 1, figs. 12-15. Depth 2923 to 2932 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 1, figs. 12-15. Slide No. FA2923 to 2932-3; co-ord. 20.8/54.2.

Lycospora cretacea Pocock, 1962

Plate 1, figure 16

1962 Lycospora cretacea Pocock, Palaeontographica B, 111, p. 34, pl. 1, figs. 12-13.

DESCRIPTION: Trilete; laesurae reach the margin of the central body but do not extend onto the cingulum; equatorial outline subcircular to subtriangular; cingulate; cingulum 4 microns wide thinning towards equatorial margin; exine ornamented with scattered low verrucae; ornamentation reduced on proximal side.

SIZE RANGE: Equatorial diameter 35 to 60 microns.

DISTRIBUTION: Lower Cretaceous. More common in the Lower Mannville strata.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 1, fig. 16. Depth 1781 to 1791 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 1, fig. 16. Slide No. Micro. 91; co-ord. 3.4/37.1.

FAMILY SELAGINELLACEAE

Genus Acanthotriletes (Naumova, 1937? 1939) ex Potonie and Kremp, 1954

- 1937 Acanthotriletes Naumova, Spores and pollen of the coals of the U.S.S.R. 17th Int. Geol. Congr. Abstracts of Papers, pp. 60-61.
 1950 Spinoso-sporites ciliatus Knox, Trans. and Proc. Bot. Soc. Edin., p. 313, pl. 17, fig. 206.
 1954 Acanthotriletes ciliatus (Knox) Potonie and Kremp, Palaeontographica B, 98, p. 83, pl. 14, fig. 257, (type species).

DIAGNOSIS: Trilete; ciliate; spines closely crowded, attenuate, longer than twice their diameter.

Acanthotriletes varispinosus Pocock, 1962

Plate 1, figures 17, 18

- 1962 Acanthotriletes varispinosus Pocock, Palaeontographica B, 111, p. 36, pl. 1, figs. 18-20.

DESCRIPTION: Trilete; laesurae about 3/4 of radius of spore; equatorial outline subcircular to subtriangular; proximal face flat, exine scabrate; distal face convex, exine spinose; spines pointed, about 6 microns long, base about 2 to 4 microns wide; distribution of spines irregular.

SIZE RANGE: Equatorial diameter 20 to 40 microns.

DISTRIBUTION: Lower Cretaceous. Rare.

AFFINITY: This species closely resembles the spores of the recent species Selaginella kraussiana and S. selaginoides.

LOCALITY OF FIGURED SPECIMENS: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

- Pl. 1, fig. 17. Depth 1816 to 1826 feet; Grand Rapids Formation.
 Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).
 Pl. 1, fig. 18. Depth 3850 to 3860 feet; Ellerslie Member.
 REPOSITORY: Res. Coun. Alberta Palynological Type Coll.
 Pl. 1, fig. 17. Slide No. IW1816-1826-3; co-ord. 14/42.
 Pl. 1, fig. 18. Slide No. Micro. 59; co-ord. 6/44.

Acanthotriletes levidensis Balme, 1957

Plate 1, figure 19

- 1957 Acanthotriletes levidensis Balme, C.S.I.R., Australia, Coal Res. Sect.,
 Ref. T.C.25, p. 18, pl. 1, figs. 18-19.

DESCRIPTION: Trilete; laesurae distinct, extending up to the margin, raised;
 ornamented on the distal side only by regularly arranged conical processes 2 microns
 long and 1 micron wide at the base.

SIZE RANGE: Equatorial diameter 20 to 35 microns.

DISTRIBUTION: Lower Cretaceous. Rare. Also found in the Lower Cretaceous
 of Perth Basin, Western Australia (Balme, 1957).

AFFINITY: This species closely resembles spores of the recent species
Selaginella subarborescens (Knox, 1950).

LOCALITY OF FIGURED SPECIMEN: Imperial Namao No. 1 well (Lsd. 12,
 Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

- Pl. 1, fig. 19. Depth 3768 to 3778 feet; Ellerslie Member.
 REPOSITORY: Res. Coun. Alberta Palynological Type Coll.
 Pl. 1, fig. 19. Slide No. Micro. 53; co-ord. 10.5/49.5.

FAMILY OSMUNDACEAE

Genus Osmundacidites Couper, 1953

- 1953 Osmundacidites wellmanii Couper, N. Z. Geol. Surv. Pal. Bull. 22, p. 20,
 pl. 1, fig. 5, (type species).

DIAGNOSIS: Trilete; laesurae about 3/4 of the radius of spore; equatorial outline circular, but frequently folded; exine ornamented with granular papillate structures.

Osmundacidites wellmanii Couper, 1953

Plate 1, figure 20

1953 Osmundacidites wellmanii Couper, N. Z. Geol. Surv. Pal. Bull. 22, p. 20, pl. 1, fig. 5.

DESCRIPTION: Trilete; laesurae about 3/4 of radius of spore, simple; equatorial outline circular; exine 1 micron thick, with granular papillate structure; projections up to 1 micron above the surface.

SIZE RANGE: Equatorial diameter 35 to 55 microns.

DISTRIBUTION: Jurassic and Lower Cretaceous. Common.

AFFINITY: This species closely resembles Todites hartzi Harris, 1931 and Osmundopsis plectophora Harris, 1931 from the Lias of Greenland.

REMARKS: Sporites primarius Wolff, 1934, has been designated as the type species of Baculatisporites Thomson and Pflug, 1953, which it closely resembles; therefore, the genus Osmundasporites is now invalid because it has lost its type species.

Balme considers Osmundacidites comaumensis (Cookson) Balme, 1957 to be similar to but not identical with O. wellmanii, the latter having smaller and more regular ornamental processes. Osmunda-sporites elongatus Rouse, 1957, which has a size range of 55 to 89 microns is larger than O. wellmanii. The placing of these species in synonymy with O. wellmanii by Pocock (1962) is not considered to be justified because of the several distinct types of ornamentation that occur on

Mesozoic osmundaceous spores.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well
(Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 1, fig. 20. Depth 1826 to 1836 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 1, fig. 20. Slide No. IW 1826-1836-5; co-ord. 14.1/56.

Genus Rugulatisporites Pflug, in Thomson and Pflug, 1953

1953 Rugulatisporites quintus Thomson and Pflug, Palaeontographica B, 94,
p. 56, pl. 2, fig. 46, (type species).

DIAGNOSIS: Trilete; laesurae faint, about 2/3 of the spore radius; equatorial
outline roughly circular; exine ornamented with short rugulate muri or warts;
distribution of rugulae irregular but dense.

Rugulatisporites sp.

Plate 1, figure 21

DESCRIPTION: Trilete; laesurae indistinct, extending up to 2/3 of the spore
radius; equatorial outline rounded-triangular; exine thick and ornamented with densely
packed rugulae both on proximal and distal surfaces.

SIZE RANGE: Equatorial diameter 42 microns.

DISTRIBUTION: Barremian? to Aptian. Very rare. A single specimen was
recorded from the Ellerslie Member.

AFFINITY: It is similar to the spores of the extant species Osmunda regalis,
and hence has probable affinities with the family Osmundaceae.

REMARKS: This species has not been formally described as only one
specimen assignable to it was found. Hence, it was not possible to determine the

range of variation within the species.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 1, fig. 21. Depth 3075 to 3084 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 1, fig. 21. Slide No. Micro. 234; co-ord. 9.1/41.5

Genus Todisporites Couper, 1958

1958 Todisporites major Couper, Palaeontographica B, 103, p. 134, pl. 16, figs. 6-8, (type species).

DIAGNOSIS: Trilete; laesurae simple, more than $2/3$ radius of spore;

equatorial outline more or less circular; exine thin, smooth to finely scabrate.

Todisporites minor Couper, 1958

Plate 1, figure 22

1958 Todisporites minor Couper, Palaeontographica B, 103, p. 135, pl. 16, figs. 9, 10.

DESCRIPTION: Trilete; laesurae simple, more than $3/4$ radius of spore;

equatorial outline circular; frequently folded; exine thin and smooth.

SIZE RANGE: Equatorial diameter 30 to 50 microns.

DISTRIBUTION: Middle Jurassic to Lower Cretaceous. Rare. This species was first described from the Gristhorpe beds (Bajocian) of England, by Couper (1958).

It has been recorded from the upper Fernie shale to the top of the Mannville Group in western Canada.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 1, fig. 22. Depth 2607 to 2616 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.
Pl. 1, fig. 22. Slide No. Micro. 187; co-ord. 11.5/40.5.

FAMILY SCHIZAEACEAE

Genus Appendicisporites Weyland and Krieger, 1953

1953 Appendicisporites tricuspidatus Weyland and Greifeld, Palaeontographica B, 95, p. 42, pl. 11, fig. 54, (type species).

DIAGNOSIS: Trilete; exine two-layered with a thick ectexine layer; equatorial outline more or less triangular; apical appendices short and conical or very long in which case they equal or exceed the equatorial diameter of the central body; ectexine covered with broad partially branching ridges more or less parallel to the equatorial sides of the spore; the ridges in the polar regions slightly bent towards the pole.

Appendicisporites tricornitatus Weyland and Greifeld, 1953

Plate 2, figure 1

1953 Appendicisporites tricornitatus Weyland and Greifeld, Palaeontographica B, 95, p. 43, pl. 11, fig. 52.

DESCRIPTION: Trilete; laesurae about $3/4$ of the radius of spore; commissures raised on some specimens; equatorial outline triangular; distal face convex, ornamented with ridges 2 to 4 microns wide and spaced 1 to 4 microns apart, parallel to the sides of the spore; apical appendices 5 to 9 microns long.

SIZE RANGE: Equatorial diameter 40 to 65 microns.

DISTRIBUTION: Cretaceous. Abundant. First described from the Lower Senonian of Germany (Weyland and Greifeld, 1953). A key form making its first appearance at the top of the Berriasian Stage in northwest Europe (Hughes, 1958). This species makes its first appearance in western Canada in the Deville Member.

REMARKS: In their original description of Appendicisporites tricomitatus Weyland and Greifeld, 1953 refer to the apical appendices as small "thimble-like" projections. Couper (1958) restricted the size of apical appendices between 5 to 9 microns for spores with equatorial diameter between 45 to 65 microns. In all other descriptions and illustrations (Delcourt and Sprumont, 1955, Groot and Penny, 1960 etc.) the apical appendix is always less than 1/6 of the diameter of the spore, and is just a small blunt process. A. tricornitatus illustrated by Pocock (1962, pl. 2, fig. 24) has processes that appear to be too long to be included in that species.

The generic name Appendicisporites was proposed by Weyland and Krieger (1953), who designated Weyland and Greifeld's species A. tricuspidatus, described in the same publication, as the type species.

LOCALITY OF FIGURED SPECIMEN: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 2, fig. 1. Depth 3706 to 3716 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 2, fig. 1. Slide No. Micro. 17; co-ord. 20/49.

Appendicisporites crickmayii Pocock, in press

Plate 2, figures 2, 3

In press Appendicisporites crickmayii Pocock, Grana Palyn., vol. 5.

DESCRIPTION: Trilete; laesurae simple slits, reaching up to the margin of

endexine in the apices; a distinct margo borders the laesurae; equatorial outline triangular; sides straight to slightly concave; endexine is smooth and thin; ekstexine is about 2 microns thick in the interapical section becoming thicker at the apices to form hollow, rounded appendices between 6 to 10 microns long, 8 to 14 microns wide and about 10 microns thick; both proximal and distal ekstexine is ornamented with three sets of ribs about 1.5 microns wide, spaced 1 micron apart, each set paralleling one side of the spore and adjacent sets fusing at the apices, ribs are often corrugated.

SIZE RANGE: Equatorial diameter 35 to 48 microns.

DISTRIBUTION: Barremian? to Middle Albian. This species is quite common at the base of the Ellerslie Member in central Alberta, where it makes its first appearance in the section. It has been reported as rare from the Upper Mannville equivalents in Saskatchewan by Pocock (in press).

REMARKS: The dimensions of the appendices and the outline of the sides in Appendicisporites crickmayii are variable. Figures 2 and 3 on plate 2 illustrate the range of variation within this species. Figure 3 is closer to the holotype.

LOCALITY OF FIGURED SPECIMENS: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 2, fig. 2, 3. Depth 3850 to 3860 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 2, fig. 2. Slide No. Micro. 267; co-ord. 9/39.4.

Pl. 2, fig. 3. Slide No. Micro. 267; co-ord. 10/49.8.

Appendicisporites jansonii Pocock, 1962

Plate 2, figure 4

DESCRIPTION: Trilete; laesurae reach the margin of endexine in the apices; commissures raised; equatorial outline triangular; sides straight; spore wall composed of two layers; endexine thin and smooth; ectexine ornamented on both proximal and distal faces with ridges about 3 microns wide and parallel to the sides, often branching, separated by furrows 1 micron wide; ridges fuse at the apices; ectexine thickens at the apices forming thick blunt apical knobs which are 8 to 12 microns long; exine thick.

SIZE RANGE: Equatorial diameter 56 to 147 microns. Average 100 microns.

DISTRIBUTION: Barremian? and Aptian. Common. According to Pocock (1962) this key form is restricted to the Ellerslie and Calcareous Members. However, in central Alberta this species was found to be abundant in the Deville Member, thus extending the range.

REMARKS: This species can be distinguished from A. tricornitatus by its thick blunt apical knobs, straight sides, and larger size. Its size range has been extended from 56 (74) 87 microns (Pocock, 1962, p. 37) to 56 (100) 147 after measuring 20 specimens.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 2, fig. 4. Depth 3213 to 3222 feet; Deville Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 2, fig. 4. Slide No. Micro. 259; co-ord. 9.3/42.1.

Appendicisporites erdtmanii Pocock, in press

Plate 2, figures 5-7

In press Appendicisporites erdtmanii Pocock, Grana Palyn., vol. 5.

DESCRIPTION: Trilete; laesurae simple slits extending up to approximately

2/3 of the spore radius; equatorial outline triangular; sides convex; apices sharp; endexine thin and smooth; ectexine thick, ornamented on the proximal surface by ribs 3 to 4 microns wide, spaced about 1 micron apart, running parallel to the sides of the spore; ribs from the adjacent sides fuse in pairs near the apices; distal ribs also run parallel to the sides except in the innermost area about 15 microns across over the distal pole where three ribs join to form a triangle about 5 microns across; ribs extend from the apices of this triangle and join the adjacent ribs as illustrated on pl. 2 fig. 7; ectexine is thickened on the apices to form conical appendices about 6 microns long and 7 microns wide.

SIZE RANGE: Equatorial diameter 50 to 55 microns.

DISTRIBUTION: Barremian? to Middle Albian. Common. In central Alberta this species occurs throughout the Mannville Group. Pocock (in press) described it from the Upper Mannville equivalents of Saskatchewan.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 2, figs. 5-7. Depth 1781 to 1791 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 2, figs. 5-7. Slide No. Micro. 113; co-ord. 9.6/38.2.

Appendicisporites cooksonii (Balme) Pocock, in press

Plate 2, figures 8-10

- 1939 Anemia mitriiformina Korzhenevskaya, Report VSEGEI, Leningrad.
- 1957 Cicatricosisporites cooksonii Balme, C.S.I.R., Australia, Coal Research Section, Reference T.C. 25, p. 19, Pls. 1 and 2, figs. 23-26.
- 1958 Anemia mitriiformina (Korzhenevskaya) Verbitskaya, Spore pollen complexes from Cretaceous sediments of Sutchenski Coal Basin, Russia, pl. 2, figs. 37-37a.
- 1961 Anemia cooksonii (Balme) Bolkhovitina, Acad. Sci. U.S.S.R., Trans. Geol. Inst., vol. 40, p. 59, pl. 17, figs. 6a-e.

In press Appendicisporites cf. A. cooksonii (Balme) Pocock, Grana Palyn., vol. 5.

DESCRIPTION: Trilete; laesurae simple straight slits, 20 microns long, extending up to the margin of endexine in the apices, bordered by a 2 microns wide margo; equatorial outline rounded triangular; sides convex; apical angle well rounded; endexine thin and smooth; ectexine about 4 microns thick in the interapical section, thickening up to 12 microns at the apices forming very broadly rounded blunt appendices; proximal ectexine ornamented by flat, 5 microns wide ribs, separated by furrows about 1.5 microns wide, with three ribs in each interapical area, parallel to their side, the outer rib forming an equatorial girdle; distal ectexine ornamented by a series of parallel rounded ribs, 5 microns wide, separated by furrows about 1.5 microns wide and disposed obliquely to one side of the spore from the opposite apex, these distal ribs merge with the equatorial girdle.

SIZE RANGE: Equatorial diameter 45 to 55 microns.

DISTRIBUTION: Callovian to Albian. Abundant in the Deville Member. In central Alberta this species was found in the Deville and Ellerslie Members only. It has also been reported from the Upper Mannville equivalents in Saskatchewan by Pocock (in press). Balme (1957) described this species from Callovian to Albian of Western Australia and Queensland.

REMARKS: Although Balme (1957) makes no mention of appendices or proximal rib pattern, both these features are visible on the specimens illustrated by him on plate 1, figure 23. There is no doubt that the Canadian specimens are conspecific with those illustrated by Balme from Australia. They are identical both in size range as well as in ornamentation.

Anemia mitriformina Korzhenevskaya, 1939 was not illustrated or validly published. Therefore, C. cooksonii Balme, 1957 has priority.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 2, figs. 8-10. Depth 3213 to 3222 feet; Deville Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 2, figs. 8-10. Slide No. Micro. 261; co-ord. 11.8/40.8.

Appendicisporites crimensis (Bolkhovitina) Pocock, in press

Plate 2, figures 11, 12

1961 Anemia crimensis Bolkhovitina, Acad. Sci. U.S.S.R., Trans. Geol. Inst., vol. 40, p. 55, pl. 15, fig. 8, pl. 17, fig. 7.

In press Appendicisporites cf. A. crimensis (Bolkhovitina) Pocock, Grana Palyn., vol. 5.

DESCRIPTION: Trilete; laesurae simple slits, extending up to the margin of the endexine in the apices, bordered by raised lips; equatorial outline triangular; sides slightly convex; apices sharp; endexine smooth and thin; ectexine thickened at the apices to form broad and blunt appendices; both the proximal and distal ectexine ornamented by a few flat ribs about 3 to 4 microns wide, separated by furrows 0.5 microns wide; each set of ribs runs parallel to its side of the spore and merges with the adjacent set near the apices.

SIZE RANGE: Equatorial diameter 38 to 50 microns.

DISTRIBUTION: Hauterivian to Albian. Common. In central Alberta this species is abundant in the Upper Mannville and common in the Lower Mannville strata. It has also been reported from the Upper Mannville equivalents of Saskatchewan, Pocock (in press). It was first described from Russia where it occurs in the Hauterivian of Crimea, the Neocomian of Caucasus and the Albian of Kazakistan.

REMARKS: Under a taxonomic approach which favours the use of natural genera these specimens would be placed under Anemia crimensis.

The Canadian specimens of A. crimensis appear to be identical with the specimen illustrated on plate 17, figure 7 by Bolkhovitina (1961). However, the author must have extended the limits of specific variation to an extreme to include the specimen illustrated on plate 15, figure 8 in the same publication, which is unlike the Canadian specimens. Bolkhovitina uses the protruding spherical shape of the appendices to distinguish this species from Anemia macrorhyza. But at the same time she mentions that there are intergrading forms between these two species. The Canadian specimens are smaller than the Russian specimens of A. crimensis, which are between 50 to 60 microns in size. They also lack the characteristic protruding spherical appendices. It has not been placed in A. macrorhyza because the latter has even larger dimensions than A. crimensis.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 2, figs. 11, 12. Depth 1816 to 1826 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 2, figs. 11, 12. Slide No. Micro. 121; co-ord. 10.8/44.

Appendicisporites cf. A. pschekhaensis (Bolkhovitina) Pocock, in press

Plate 2, figure 13

1961 Anemia pschekhaensis Bolkhovitina, Acad. Sci. U.S.S.R., Trans. Geol. Inst., vol. 40, p. 55, pl. 15, fig. 9.

In press Appendicisporites cf. A. pschekhaensis (Bolkhovitina) Pocock, Grana Palyn., vol. 5.

DESCRIPTION: Trilete; laesurae reaching up to the margin of endexine in the

apices; equatorial outline triangular; sides straight to slightly convex; endexine smooth and thin; ectexine about 3 microns thick and forms an equatorial girdle about 2 microns wide, thickened at the apices to form appendices about 14 microns long and about 6 microns wide; proximal and distal surfaces ornamented with ribs about 2 to 3 microns wide and spaced 1 to 3 microns apart, running parallel to the sides of the spore and fusing at the apices with the appendices; on distal face three adjacent ribs merge with each appendix, on the proximal face three ribs on each side run internally parallel to equatorial girdle.

SIZE RANGE: Equatorial diameter (including appendices) about 58 microns.

DISTRIBUTION: Neocomian to Middle Albian. Rare. In central Alberta this species is more common in the uppermost portion of the Grand Rapids Formation but occurs throughout the Mannville Group. It has also been reported from the Upper Mannville equivalents of Saskatchewan by Pocock (in press). This species was first described from the Neocomian Stage of Russia.

REMARKS: Under a taxonomic approach which favours the use of natural genera these specimens would be placed under Anemia pschekhaensis.

The holotype of A. pschekhaensis has big slightly elongated club-like appendices. A. cf. A. pschekhaensis has long slightly tapering appendices. It is also smaller than the Russian specimens which have a size range between 70 to 80 microns.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 2, fig. 13. Depth 1781 to 1791 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 2, fig. 13. Slide No. Micro. 95; co-ord. 7.9/35.4.

Appendicisporites sp.

Plate 2, figure 14

DESCRIPTION: Trilete; laesurae indistinct, probably reach the margin of the endexine in the apices; equatorial outline triangular; sides concave; ectexine ornamented both on proximal as well as distal faces with 4 or 5 ribs, each about 6 microns wide, parallel to the sides, fusing at apices and spaced about 2 to 3 microns apart; ectexine comparatively thin in the interapical areas, becoming thicker at the apices to form hollow and rounded appendices about 25 microns long, 25 microns wide and 20 microns thick.

SIZE RANGE: Equatorial diameter 84 microns.

DISTRIBUTION: Barremian? Very rare. In central Alberta a single specimen of this species was recorded from the top of the Deville Member.

REMARKS: This specimen differs from Appendicisporites jansonii in having concave instead of straight sides, wider and fewer ribs and larger appendices.

This species has not been formally described as only one specimen assignable to it was found on the basis of which it was not possible to determine the range of variation within the species.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 2, fig. 14. Depth 3213 to 3222 feet; Deville Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 2, fig. 14. Slide No. Micro. 260; co-ord. 12.5/46.2.

Appendicisporites trichacanthus (Maljavkina) var. dissectus (Markova) n. comb.

Plate 3, figures 1-6

- 1961 Anemia trichacantha (Maljavkina) var. dissecta Markova, Trans. of the All Union Petr. Sci. Res., Geol. Surv. Inst., vol. 177, p. 73, pl. 18, figs. 3a-c.

DESCRIPTION: Trilete; laesurae straight with slightly raised lips, equal to the radius of the spore, extending to the base of the appendices; equatorial outline triangular with slightly convex sides; endexine smooth and thin; ectexine thick and coarse, thickened at the apices to form slightly elongated to rounded appendices 14 microns wide, and 11 to 14 microns long; the ectexine on the proximal side ornamented with tightly packed ribs 3 to 6 microns wide, spaced about 1 micron apart, running parallel to the sides of the spore; on the distal side also the ribs run parallel to the sides and have the same dimensions as the proximal ones but the ends of the adjacent ribs fuse to form a ridge running from the inner area to the appendices, the distal rib pattern is illustrated on plate 3, figure 3; the surface of both the proximal and distal ribs perforated by double or triple rows of pores, in most places these pores join to give rise to numerous transverse grooves making notches on the margin of the ribs (plate 3, figure 6).

SIZE RANGE: Equatorial diameter (including appendices) 97 microns.

DISTRIBUTION: Albian to Cenomanian. Very rare. A single specimen of this species was recorded in central Alberta near the base of the Wabiskaw Member. It was first described from the Albian and Cenomanian Stages of western Siberia.

REMARKS: Under a taxonomic approach which favours the use of natural genera these specimens would be placed under Anemia trichacantha (Maljavkina) var. dissecta Markova.

The Canadian specimen of A. trichacanthus var. dissectus is larger in size as compared with the Russian holotype which has an equatorial diameter of only 68

microns. The ribs are also slightly wider on the Canadian specimen. Markova (1961) only mentions "numerous transverse grooves" on the surface of the ribs, which, however, could arise in the manner explained above. In so far as A. trichacanthus var. dissectus was described by Markova on the basis of only two specimens the range of variation within this species could not be established firmly. Therefore, in spite of its larger dimensions, the Canadian specimen is considered close enough to the holotype, for its inclusion in the species A. trichacanthus var. dissectus.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 3, figs. 1-6. Depth 2932 to 2938 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 3, figs. 1-6. Slide No. Micro. 217; co-ord. 10/39.9.

Appendicisporites cf. Anemia trichacantha (Maljavkina) Markova, 1961

Plate 4, figures 1-3

- 1949 (?) Plicatella trichacantha f. typica Maljavkina, Designation of spores and pollen in Jurassic and Cretaceous, p. 61, pl. 11, fig. 7.
- 1958 Anemia aurifera Verbitskaya, Spore and pollen complexes of Cretaceous deposits of Sutchanski Coal Basin, p. 317, pl. 2, fig. 38.
- 1961 Anemia trichacantha (Maljavkina) Markova, Trans. of the All Union Petr. Sci. Res., Geol. Surv. Inst., vol. 177, p. 73, pl. 18, figs. 2a-c.
- In press Appendicisporites trichacanthus trichacanthus (Maljavkina) Pocock, Grana Palyn., vol. 5.

DESCRIPTION: Trilete; commissures raised, distinct only up to 1/2 of the spore radius, obscured by merging with the ribs near the apices; equatorial outline triangular with straight to slightly convex sides; apices sharp with appendices about 8-12 microns long and 6 microns wide; endexine thin and smooth; ectexine thick with a proximal ornamentation of three sets of ribs, each parallel to its side of spore; ribs 2 microns wide spaced from 1 to 2 microns apart; area around the raised

laesurae smooth; distal ornamentation composed of first set of ribs forming an equatorial girdle, second set of ribs connecting the apices and more or less parallel to the commissures on the proximal side, and third innermost set of ribs with an irregular pattern.

SIZE RANGE: Equatorial diameter 50 to 65 microns.

DISTRIBUTION: Aptian to Cenomanian. Rare. In western Canada this species appears to be well represented in the Upper Mannville strata. Recorded from the Aptian, Albian and Cenomanian Stages of Russia.

REMARKS: In the description of Anemia trichacantha, Markova (1961) mentions that the laesurae are equal to the radius of the spore. It may be so but on most of the specimens examined the commissures are raised and distinct only up to 1/2 the radius of the spore, they appear to continue beyond that but they merge with the rib pattern and are lost. The appendices are definitely larger on the Russian specimens, ranging between 13 to 17 microns in length and 10 microns in width. Markova appears not to have noticed the details of the distal ornamentation which are not the same as on the proximal face. The specimens described by Markova (1961) have a size range between 53 to 60 microns whereas Maljavkina's (1949) specimens had a size range between 120 to 140 microns, yet they have been treated as the same species. This brings in a degree of uncertainty. The specimens should perhaps be re-examined and the species revised because such a range of variation within the species appears to be improbable.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).
Pl. 4, figs. 1-3. Depth 2905 to 2914 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.
 Pl. 4, figs. 1-3. Slide No. FA2905-2914-2; co-ord. 20.8/52.

Appendicisporites unicus (Markova) n. comb.

Plate 4, figures 4-6

1961 Anemia unica Markova, Trans. of the All Union Petr. Sci. Res., Geol. Surv. Inst., vol. 177, p. 79, pl. 20, figs. 3a-b.

DESCRIPTION: Trilete; laesurae straight and simple slits, equal to the radius of the body; equatorial outline triangular with straight to slightly convex sides; apical appendices thin, elongated, slightly swollen and rounded at the tips, 14 microns long and between 3 to 4 microns wide; a few smaller projections continuous with the ribs present at the base of each appendix; proximal face ornamented by about 4 sets of ribs each 2 to 4 microns wide, parallel to their sides, and spaced from 2 to 4 microns apart; on the distal face only the outer two ribs are parallel to their sides; the rest of the inner area ornamented by ribs running along a curvature between two sides as shown on plate 4, figure 6; distal ribs corrugate.

SIZE RANGE: Equatorial diameter of body (without appendices) 38 microns.

Length of appendices about 14 microns.

DISTRIBUTION: Albian to Cenomanian. Very rare. Two specimens of this species were recorded in central Alberta from the Grand Rapids Formation. It was first described from the Cenomanian Stage of Siberia.

REMARKS: Under a taxonomic approach which favours the use of natural genera these specimens would be placed under Anemia unica.

The Canadian specimen of A. unicus appears to be identical with those

illustrated and described from Russia. However, Markova has neither illustrated nor described the details of the distal ornamentation.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 4, figs. 4-6. Depth 2607 to 2616 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 4, figs. 4-6. Slide No. Micro. 186; co-ord. 11.8/39.5.

Appendicisporites bifurcatus n. sp.

Plate 5, figures 1-5

DESCRIPTION: Trilete; laesurae simple and straight slits, extending to the margin of endexine at the base of the appendices, bordered by a thickened margo on either side that is 5 microns wide; equatorial outline circular to triangular with convex sides; endexine thin and smooth; ectexine thick, forming very thick appendices about 20 microns long and about 12 to 15 microns wide at the apices; appendices very thick in a vertical section and usually split into two to three branches depending upon the degree of inflation of the spore; ectexine on the proximal side ornamented by about 15 sets of ribs, each about 2 microns wide and spaced about 0.5 microns apart, and parallel to each side; the ribs closer to the centre of the spore merge at their extremities with the thickened margo bordering the laesurae, only the outer ribs reaching the apices; ectexine on the distal side ornamented by the same number of ribs with similar width and spacing; the ribs closer to the outer margin converge at the base of the appendices; but each rib at the distal pole fuses with the one just outside it and so on, till the last one reaching to the apex; a triangular area about 15 microns in diameter is cut off at the distal pole with complex ribbing pattern,

having ribs parallel to only two sides; ribs often branched; the view illustrated on plate 5, figure 5 shows the distal ornamentation in this species.

SIZE RANGE: Equatorial diameter(including appendices) 85 to 95 microns.

Equatorial diameter of the holotype (including appendices)

94 microns.

DISTRIBUTION: Middle Albian. Rare. In central Alberta this species was recorded from the Shale Member of the Clearwater Formation and the Grand Rapids Formation.

TYPE LOCALITY: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Holotype: Pl. 5, figs. 1, 2, 4, 5. Depth 2842 to 2851 feet; Clearwater Formation, Shale Member.

Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 5, fig. 3. Depth 1911 to 1921 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 5, figs. 1, 2, 4, 5. Slide No. 203; co-ord. 11.5/40.9.

Pl. 5, fig. 3. Slide No. 153; co-ord. 12.5/38.

Appendicisporites perplexus n. sp.

Plate 5, figures 6-9

DESCRIPTION: Trilete; laesurae simple slits or slightly gaping, bordered by thickened lips which become narrower and thinner towards the extremities; laesurae about 3/4 of the spore radius, extending up to the base of the appendices; equatorial outline triangular with straight sides and rounded apices; proximal exine thin and smooth, thickened only in the area bordering the laesurae; the ribbing pattern consists of an equatorial girdle about 5 microns wide; distal surface convex; distal exine ornamented by a thickened triangular shield probably due to an extreme

development and fusion of the ribs; the sides of thickened shield concave, the inner area of the shield variously excavated with holes (X, Y, and Z) which represent the reduced furrows between the ribs; the ornamentation pattern in the inner area very variable; the average pattern roughly indicates that the shield splits into another set of single inner ribs, each parallel to the sides of the shield; mode of separation of these inner ribs very variable, often indicated by an irregular large hole, resulting in complete separation or just a narrow groove, the distal triangular shield is at a higher level than the equatorial girdle and has a diameter of about 35 microns; the apices of the shield thickened to form internal cushions about 7 microns long and equally wide where they meet the equatorial girdle.

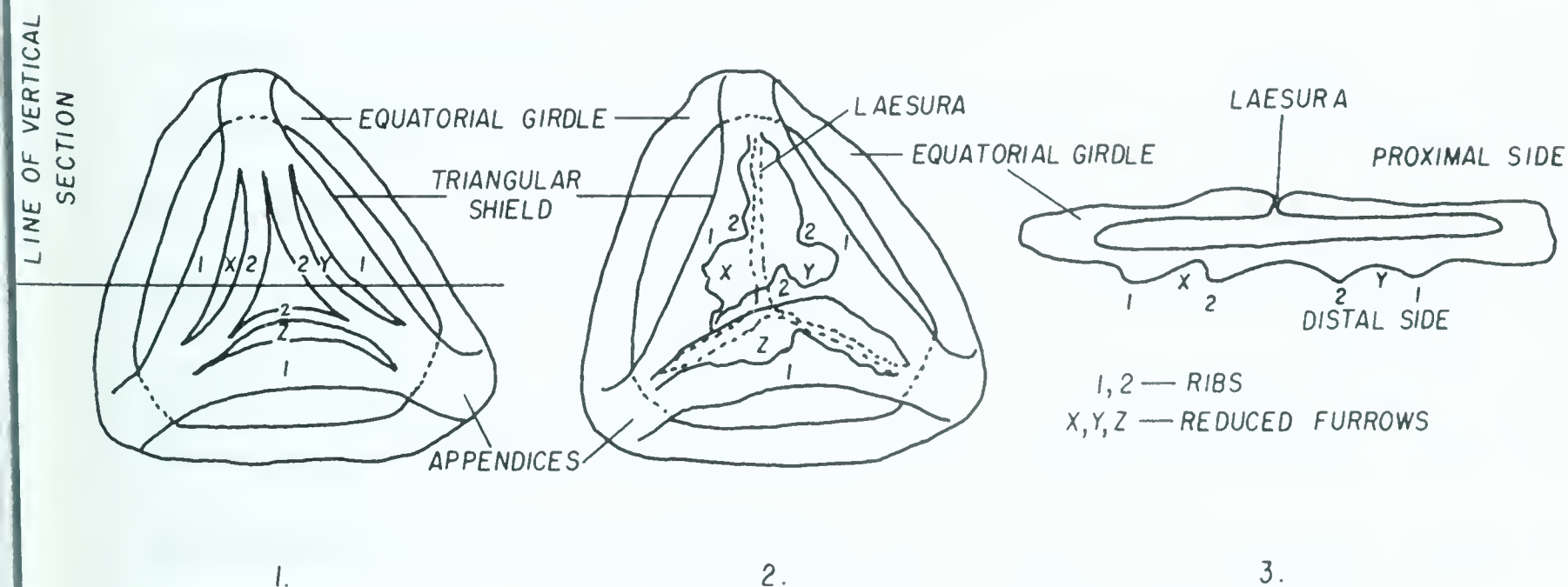


Figure 8. *Appendicisporites perplexus* n. sp.

1. Diagrammatic interpretation of distal ornamentation. 2. Actual distal ornamentation. 3. Vertical section.

SIZE RANGE: Equatorial diameter 34 (41) 45 microns.

Equatorial diameter of the holotype 44.2 microns.

DISTRIBUTION: Middle Albian. Abundant. In central Alberta this species makes its appearance abruptly at the base of the Clearwater Formation. It is abundant

in the Middle Albian, brackish to marine sediments disappearing in the continental beds near the top of the Grand Rapids Formation. This species, being quite abundant, is an important stratigraphic marker, with a wide regional but restricted stratigraphic distribution.

REMARKS: Spores similar to Appendicisporites perplexus n. sp. have been described by Pocock (in press) as A. degeneratus Thiergart, 1953. There are very few points of similarity between the Canadian specimens and the holotype of A. degeneratus Thiergart, 1953 (Palaeontographica B, 95, p. 55, pl. 14, fig. 4) which was described from the Cenomanian of Germany. In order to determine the size range of the Canadian specimens the equatorial diameters of 20 spores were measured. The result was as follows: 9 spores: 40.8 microns, 5 spores: 43.2 microns, 2 spores: 39.1 microns, 2 spores: 34 microns and 1 spore: 44.2 microns. Spores with a larger equatorial diameter than 45 microns were not encountered on further checking. The above measurements indicate that the size of this species is fairly uniform, mostly remaining within 40 to 45 microns range. As compared to this the equatorial diameter of the holotype of A. degeneratus is 80 microns. While the appendices in the Canadian specimens seldom protrude beyond the apical margin, the holotype of A. degeneratus has been illustrated and described by Thiergart as having "projections on the apices forming short horns" (translation from German). A. degeneratus has a distinct and prominent rib pattern on the distal face, whereas the Canadian specimens have only a sort of a thickened, triangular distal shield excavated in various manners by holes or furrows which only vaguely resemble a rib pattern. The distinct discontinuity in size frequency and the above-mentioned

morphological differences between A. degeneratus and the Canadian specimens justify the creation of Appendicisporites perplexus n. sp.

Zonales Bennie and Kidston, (Thiergart, 1953, p. 57, pl. 14, fig. 5) which has a size range of 74 to 92 microns is similar to A. perplexus in so far as this too has an equatorial girdle and inner triangular zone. However, it is larger, with no appendices, and the details of ornamentation on the inner triangular zone are not clear. It has not been validly published.

TYPE LOCALITY: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Holotype: Pl. 5, figs. 6, 8, 9. Depth 2496 to 2505 feet; Grand Rapids Formation.
Pl. 5, fig. 7. Depth 2842 to 2851 feet; Clearwater Formation,
Shale Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 5, figs. 6, 8, 9. Slide No. Micro. 174; co-ord. 10.8/38.5.
Pl. 5, fig. 7. Slide No. FA2842-2851-4; co-ord. 10.5/71.

Genus Cicatricosisporites Potonie and Gelletich, 1933

- 1933 Cicatricosisporites dorogensis Potonie and Gelletich, Sitz. Ber. Ges. Naturf. Freunde, Berlin, p. 522, pl. 1, figs. 1-5, (type species).
- 1949 Mohria - Typus, Thiergart, Palaeontographica B, 89, p. 22.
- 1950 Mohrioidites Thiergart, Geol. Jb., 65, p. 84.
- 1951 Mohriosisporites Potonie, Palaeontographica B, 91, p. 135.
- 1953 Mohriosisporites Cookson, Aust. J. Bot. 1(3), p. 470.

DIAGNOSIS: Trilete; exine two layered and sculptured with muri or ridges of uniform width and height; canaliculate to cicatricose; the muri are more or less parallel to the equator. Equatorial outline regularly crenate, with no tendency to thicken at the apices.

Cicatricosisporites dorogensis Potonie and Gelletich, 1933

- 1933 Cicatricosisporites dorogensis Potonie and Gelletich, Sitz. Ber. Ges. Naturf. Freunde, Berlin, p. 522, pl. 1, figs. 1-5.
- 1951 Mohriosisporites dorogensis Potonie, Palaeontographica B, 91, p. 135, pl. 20, fig. 14.
- 1953 Mohriosisporites australiensis Cookson, Aust. J. Bot. 1(3), p. 470, pl. 2, figs. 31-34.
- 1956 Cicatricosisporites australiensis (Cookson) Potonie, Beih. Geol. Jb., 23, p. 48.
- 1961 Mohria dorogensis (Potonie) Markova, Trans. of the All Union Petr. Sci. Res., Geol. Surv. Inst., vol. 117, p. 86, pl. 22, fig. 4.

DESCRIPTION: Trilete; laesurae reaching or almost reaching the equator; commissures may be raised; equatorial outline rounded triangular with straight, slightly convex or slightly concave sides; proximal face flat; distal face convex; ectexine ornamented with occasionally branching flat topped ribs, 1 to 5 microns broad and spaced 0.5 to 3 microns apart, oblique to the sides of the spore, present on distal as well as proximal face forming a "criss cross" pattern; wide variation in size and in thickness and spacing of ribs.

SIZE RANGE: Equatorial diameter 30 to 55 microns.

DISTRIBUTION: Purbeck to Tertiary. Locally abundant. The significance of this species lies in the fact that it makes its first appearance in the Purbeck Stage. The oldest representatives of the genus Cicatricosisporites make their first appearance in the Lias (Couper, 1958).

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 6, fig. 1. Depth 2095 to 2098 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 6, fig. 1. Slide No. IW2095-2098-1; co-ord. 0/44.

Cicatricosisporites dorsostriatus (Bolkhovitina) n. comb.

Plate 6, figures 2-4

1956 Anemia dorsostriata Bolkhovitina, Trans. Geol. Inst. Acad. Sci. U.S.S.R., No. 2, p. 60, pl. 7, figs. 95a-b.

DESCRIPTION: Trilete; laesurae extend up to the equatorial girdle, bordered by slightly thickened lips; equatorial outline rounded triangular; ornamentation consists of an equatorial girdle, 5 to 7 microns wide; ribs 10 to 12 in number, 4 to 7 microns wide, closely packed together, running completely across the distal surface including the equatorial girdle; proximal surface ornamented by an outer set of ribs running just inside the equatorial girdle; the second set of ribs inside the outer set is very wide (maximum width about 12 microns) with corrugated margin bordering the laesurae which cut across both of these inner ribs, reaching the inner margin of the equatorial girdle.

SIZE RANGE: Equatorial diameter 48 to 55 microns.

DISTRIBUTION: Middle Jurassic to Albian. Rare. In central Alberta this species makes its first appearance in the Ellerslie Member and continues into the Clearwater Formation. It has been recorded in Russia from the Middle Jurassic, the Neocomian Stage of Caucasus and the Aptian Stage of the Moscow region.

REMARKS: Under a taxonomic approach which favours the use of natural genera these specimens would be placed under Anemia dorsostriata.

The Canadian specimens of C. dorsostriatus appear to be identical with those described by Bolkhovitina (1956, 1961). However, they are slightly larger in size than the Russian specimens which have an average size of 45 microns and the maximum size of 49 microns. Bolkhovitina also does not show the distal ribs continuing onto the equatorial girdle. The details of the distal and proximal ornamentation have neither been fully illustrated nor discussed by Bolkhovitina (1956, 1961). However,

the illustration on plate 15, figure 4c by Bolkhovitina (1961) shows the proximal ornamentation with the wide corrugated ribs bordering the laesurae.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 6, figs. 2-4. Depth 2689 to 2699 feet; Clearwater Formation, Shale Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 6, figs. 2-4. Slide No. Micro. 163; co-ord. 11/41.2.

Cicatricosisporites perforatus (Baranov, Nemkova, Kondratiev) n. comb.

Plate 6, figures 5-7

1957 Anemia perforata Baranov, Nemkova, Kondratiev, Impression of leaves and spectrum of spores and pollen of a horizon with flora from Mikhailovska Formation from the river Kem, p. 202, pl. 2, fig. 22.

1961 Mohria perforata (Baranov et al.) Markova, Trans. of the All Union Petr. Sci. Res., Geol. Surv. Inst., vol. 117, p. 85, pl. 22, figs. 3a-b.

DESCRIPTION: Trilete; commissures raised with thick lips, laesurae straight and equal to the radius of the spore; equatorial outline triangular, rounded at the corners; sides convex; proximal surface ornamented by 3 to 5 sets of ribs, 3 to 5 microns wide, spaced 1 micron apart and running parallel to their side; distal surface ornamented by about 10 ribs, 4 to 6 microns wide and spaced 1 micron apart, disposed obliquely to one side of the spore from the opposite apex; a single row of holes present on both the distal as well as proximal ribs, 1 micron in diameter, distributed along their whole length and spaced about 3.5 microns apart.

SIZE RANGE: Equatorial diameter 48 to 58 microns.

DISTRIBUTION: Barremian? to Turonian. Abundant at the base of the Ellerslie Member (Barremian?). It reappears in the Colorado Group, Upper Cretaceous, Pocock (pers. comm.). In Russia this species ranges from the Aptian to Cenomanian

Stages of western Siberia and is rare in the Turonian.

REMARKS: In so far as C. perforatus has no appendices, it appears closer to Mohria than Anemia. Because of the uncertainty of the relationships, it appears preferable to place this species in Cicatricosisporites.

The Canadian specimens are larger than the Russian ones, the latter ranging between 35.4 to 36.8 microns.

LOCALITY OF FIGURED SPECIMEN: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 6, figs. 5-7. Depth 3860 to 3870 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 6, figs. 5-7. Slide No. Micro. 48; co-ord. 12.5/46.

Cicatricosisporites mediotriatus (Bolkhovitina) Pocock, 1962

Plate 6, figure 8

1961 Pelletieria mediotriata Bolkhovitina, Acad. Sci. U.S.S.R., Trans. Geol. Inst., vol. 40, p. 66, pl. 19, figs. 3a-b, pl. 21, figs. 1a-c.

In press Cicatricosisporites mediotriatus (Bolkhovitina) Pocock, Grana Palyn., vol. 5.

DESCRIPTION: Trilete; laesurae simple slits bordered by raised lips, more than 2/3 of radius of spore; equatorial outline circular to sub-circular; endexine smooth and thin; ectexine thicker, ornamented with ribs about 2 microns wide and spaced about 1 micron apart, sometimes branching; the pattern of ribbing on the proximal face irregular and not very distinct; the distal face ornamented with two sets of ribs, the ribs of the same set are parallel to one another, while they intersect the ribs of the other set forming a rhombic net.

SIZE RANGE: Equatorial diameter 40 to 50 microns.

DISTRIBUTION: Hauterivian to Turonian. Common. In central Alberta this

species was found throughout the Mannville Group. It has recently been recorded from the Upper Mannville strata of Saskatchewan by Pocock (in press).

LOCALITY OF FIGURED SPECIMEN: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 6, fig. 8. Depth 3686 to 3696 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 6, fig. 8. Slide No. Micro. 29; co-ord. 14.2/47.2.

Cicatricosisporites orbiculatus n. sp.

Plate 6, figures 9-12

DESCRIPTION: Trilete; laesurae about $3/4$ of the spore radius; commissures raised with lips 2.5 microns thick on either side; equatorial outline circular; ectexine thick and ornamented with ribs 1.5 to 2 microns wide, spaced about 0.5 microns apart; proximal surface slightly convex with about 8 ribs arranged more or less parallel to the sides, and whose arrangement may be disturbed due to compression or twisting; the ribs near the proximal pole of the spore terminate at the thickened margin of the laesurae, only the outer ribs converge at the extremities of the laesurae; distal surface markedly convex with numerous slightly sinuous ribs running right across the face from one end to the other, and forming a crenulate margin.

SIZE RANGE: Equatorial diameter about 34 microns.

Equatorial diameter of the holotype 34 microns.

DISTRIBUTION: Barremian? Rare. In central Alberta only a few specimens were found at the base of the Ellerslie Member.

TYPE LOCALITY: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Holotype: Pl. 6, figs. 9-12. Depth 3860 to 3870 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 6, figs. 9-12. Slide No. IN3860-3870-8; co-ord. 4.5/33.4.

Cicatricosisporites sp. A

Plate 7, figures 1-3

DESCRIPTION: Trilete; laesurae reaching the equatorial margin; commissures raised, thick and 8 microns wide; equatorial outline triangular with convex sides; endexine thin and smooth; ectexine thicker, ornamented with ribs about 2 microns wide and spaced 0.8 microns apart, often branching; pattern of ribbing on the proximal face oblique to the sides, approximately parallel to one of the commissures and terminating at the other commissure; distal face ornamented by branching ribs running right across the face from one end to the other, ribs disposed obliquely to the sides result in a crenulate margin.

SIZE RANGE: Equatorial diameter 60 microns.

DISTRIBUTION: Middle Albian. Very rare. In central Alberta a single specimen of this species was recorded from the base of the Wabiskaw Member.

REMARKS: This species has not been formally described as only one specimen was found.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 7, figs. 1-3. Depth 2932 to 2938 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 7, figs. 1-3. Slide No. FA2932-2938-3; co-ord. 13/37.

Cicatricosisporites sp. B

Plate 7, figures 4-6

DESCRIPTION: Trilete; laesurae simple slits extending up to 3/4 of the spore

radius; equatorial outline triangular with slightly convex sides and broadly rounded apices; ectexine on the proximal side ornamented with ribs about 3 microns wide and spaced about 0.5 microns apart, the outer 3 ribs parallel to the sides, and continuous around the apices; the inner ribs terminate at the laesurae and are discontinuous around the apices; the distal ectexine similarly ornamented with 2 to 3 outer ribs continuous around the apices, the rest of the ribs extending completely across the inner distal face.

SIZE RANGE: Equatorial diameter 46 microns.

DISTRIBUTION: Middle Albian. Very rare. In central Alberta a single specimen of this species was found in the Grand Rapids Formation.

REMARKS: The outer ribs which are continuous around the apices suggest an alliance with Chomotriletes, which has similar concentric rings. Also the obliquely oriented ribs are quite common in the genus Chomotriletes. However, the distinct trilete mark, triangular shape and the inner ribs which are discontinuous around the apices do not warrant its inclusion in the genus Chomotriletes.

This species has not been formally described, as only one specimen was found.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W.4th Mer.).

Pl. 7, figs. 4-6. Depth 2562 to 2571 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 7, figs. 4-6. Slide No. Micro. 264; co-ord. 11/37.2.

Genus Chomotriletes (Naumova, 1937) Naumova, 1953

1937 Chomotriletes Naumova, 17th Int. Geol. Congr., Absts. Papers, U.S.S.R., pp. 60-61.

1953 Chomotriletes vedugensis Naumova, Trav. Inst. Sci. Geol. 143, Ser. Geol. (No. 60), p. 39, pl. 7, fig. 21, (type species).

DIAGNOSIS: Trilete mark very faint or absent; equatorial outline irregularly circular to broadly subtriangular; very characteristic ornamentation consisting of concentric ridges on at least one face; these ridges may or may not be continuous.

Chomotriletes almegrensis Pocock, 1962

Plate 7, figure 7

1962 Chomotriletes almegrensis Pocock, Palaeontographica B, 111, p. 38, pl. 2, figs. 27-29.

DESCRIPTION: Alete; equatorial outline circular to subcircular; exine two-layered; the outer layer ornamented with ridges about 1 micron wide and 1 micron high, separated from each other by a furrow about 0.5 microns wide; on one face the ridges run obliquely across the spore, and then fold back on themselves to form a type of sulcus; on the opposite face the ridges are arranged in concentric circles parallel to the equatorial margin, the ridges are discontinuous and broken.

SIZE RANGE: Equatorial diameter 38 microns.

DISTRIBUTION: Barremian? to Middle Albian. Very rare. In central Alberta a single specimen of this species was found in the Grand Rapids Formation. Pocock (1962) described it from the Ellerslie Member. This species seems to be too rare in western Canada for an accurate determination of its stratigraphic range.

AFFINITY: The exine structure and the ornamentation indicate a schizaeaceous affinity.

REMARKS: Because of a very broad and general nature of the diagnosis of the genus Chomotriletes, some authors (Bolkhovitina 1953, p. 35) have placed in this genus forms which should probably have been assigned to Cicatricosisporites, Corrugatisporites

or Appendicisporites. However, this might have been avoided if enough attention were paid to the fact that the genus Chomotriletes has "numerous continuous or discontinuous circular and concentric ridges and the trilete mark is mostly absent or very faint".

In order to avoid further confusion it seems necessary to place only those forms in the genus Chomotriletes which have "numerous circular and concentric ridges", and to exclude trizonate forms with distinct trilete marks. Stover (1962) has proposed a new genus Taurocusporites to receive such trizonate and trilete forms. However, his emendation of the genus Chomotriletes to include only alete spores does not appear to be based on valid grounds. When Naumova (1937) first described Chomotriletes, it was mentioned that it is similar to trilete spores with concentric zones around the trilete mark as found in the Sub-division Azonotriletes Luber, 1935. However, Naumova designated a type species for the genus Chomotriletes only in 1953. In describing the type species Chomotriletes vedugensis, Naumova (1953) only mentions "mark of laesurae not observed". However, this does not mean that laesurae do not exist. In his generic diagnosis of Chomotriletes, Potonie (1958a, p. 22) states that the "trilete rays are absent or faintly developed". Also contrary to what Stover claims, Chomotriletes alutaceus Luber, 1955 does possess a trilete mark. The very fact that Naumova named the genus as Chomotriletes indicates that it was intended to be a trilete spore. Under these circumstances, the restriction to only alete forms by Stover (1962) does not appear to be justified.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 7, fig. 7. Depth 2598 to 2607 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 7, fig. 7. Slide No. Micro. 179; co-ord. 11.5/39.

Genus Schizaeoisporites Potonie, 1951

- 1934 Sporites dorogensis Potonie, Arb. Inst. Palaeob. Petr. Brennsteine 4, pp. 40, 41, pl. 1, fig. 22.
- 1944 Schizaea eocenica Selling, Medd. Fran Goteborgs Bot. Tradgord, vol. 16, p. 66, pl. 4, fig. 44.
- 1949 Sporites dorogensis (Potonie) Thiergart, Palaeontographica B, 89, pl. 4-5, figs. 35, 36.
- 1951 Schizaeoisporites pseudodorogensis Potonie, Palaeontographica B, 91, p. 144, pl. 20, fig. 19.
- 1952 Cicatricoso-sporites pseudodorogensis (Potonie) Pflug, Palaontol. Zeit. 26, pl. 7, fig. 1.
- 1956 Schizaeoisporites eocenicus (Selling) Potonie, Beih. Geol. Jb. 23, p. 81, pl. 11, fig. 108, (type species).

DIAGNOSIS: Monolete spores; cicatricose to canaliculate exine; laesura has a ridge on either side.

Schizaeoisporites eocenicus (Selling) Potonie, 1956

Plate 7, figures 8, 9

- 1934 Sporites dorogensis Potonie, Arb. Inst. Palaeob. Petr. Brennsteine 4, pp. 40, 41, pl. 1, fig. 22.
- 1944 Schizaea eocenica Selling, Medd. Fran. Goteborgs Bot. Tradgord, vol. 16, p. 66, pl. 4, fig. 44.
- 1949 Sporites dorogensis (Potonie) Thiergart, Palaeontographica B, 89, pl. 4-5, figs. 35, 36.
- 1951 Schizaeoisporites pseudodorogensis Potonie, Palaeontographica B, 91, p. 144, pl. 20, fig. 19.
- 1952 Cicatricoso-sporites pseudodorogensis (Potonie) Pflug, Palaontol. Zeit. 26, pl. 7, fig. 1.
- 1956 Schizaeoisporites eocenicus (Selling) Potonie, Beih. Geol. Jb. 23, p. 81, pl. 11, fig. 108.

DESCRIPTION: Monolete; laesura about 2/3 of total length of spore; equatorial outline bean-shaped; exine ornamented by narrow ridges, about 1.5 microns wide, which are parallel with one another and the laesura; ridges separated by furrows about 0.5 microns wide, show some tendency to converge towards the ends of the spore,

where they are continuous with ridges from the other side, frequently branched.

SIZE RANGE: Length 65 microns. Breadth 38 microns (average).

DISTRIBUTION: Lower Cretaceous to Eocene. Rare. In western Canada this species has so far been recorded from the Ellerslie Member (Pocock, 1962), and the Clearwater Formation (Shale Member). It was first described by Potonie (1934) from the Eocene sediments of Germany.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 7, fig. 8.	Depth 2833 to 2842 feet;	Clearwater Formation, Shale Member.
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Pl. 7, fig. 9.	Depth 2932 to 2938 feet;	Wabiskaw Member.
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REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 7, fig. 8.	Slide No. Micro. 202;	co-ord. 11/41.5.
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Pl. 7, fig. 9.	Slide No. Micro. 213;	co-ord. 11.5/40.
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Schizaeoisporites phaseolus Delcourt and Sprumont, 1955

Plate 7, figures 10, 11

1955 Schizaeoisporites phaseolus Delcourt and Sprumont, Mem. Soc. Belge.
Geol. n.s. 5, pp. 46-47.

DESCRIPTION: Monolete; laesura about 2/3 total length of spore; equatorial outline bean-shaped; area around the laesura unornamented; rest of the spore ornamented by parallel ridges about 2 microns wide, running obliquely to the laesura forming a "criss cross" pattern; ridges separated by furrows 1 micron wide, frequently branched and continuous with the ridges on the opposite side.

SIZE RANGE: Length 48 microns. Breadth 28 microns. (average).

DISTRIBUTION: Lower Cretaceous. First described from the "Wealden" of Belgium (Delcourt and Sprumont, 1955). Rare in western Canada.

REMARKS: The western Canadian specimens are smaller as compared with those found in Europe (length 59 to 68 microns, breadth 35 to 50 microns).

LOCALITY OF FIGURED SPECIMENS: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 7, fig. 10. Depth 1781 to 1791 feet; Grand Rapids Formation.

Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 7, fig. 11. Depth 2860 to 2869 feet; Clearwater Formation, Shale Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 7, fig. 10. Slide No. IW1781-1791-1; co-ord. 4.2/62.2.

Pl. 7, fig. 11. Slide No. Micro. 204; co-ord. 10.4/38.1.

Genus Dictyotriletes (Naumova, 1937) Potonie and Kremp, 1955

1932 Sporonites bireticulatus Ibrahim in Potonie, Neues Jahrb. Min., Geol. Pal., Beil. - Bd. 67, pt. B, pp. 447-449, pl. 14, fig. 1.

1933 Reticulatisporites bireticulatus Ibrahim, Berlin, Univ. doct. diss., p. 35, pl. 1, fig. 1.

1937 Dictyotriletes Naumova, 17th Internat. Geol. Congr., U.S.S.R., Abstr. Papers, pp. 60-61.

1955 Dictyotriletes bireticulatus (Ibrahim, 1932) Potonie and Kremp, Palaeontographica B, 98, pp. 106-107, figs. 28, 29, (type species).

DIAGNOSIS: Trilete; equatorial outline sub-triangular to sub-circular; proximal face flat, levigate; distal face reticulate, strongly convex, the mesh-structure of the exine surface is composed of low and flat muri, lumina shallow.

Dictyotriletes pseudoreticulatus (Couper) Pocock, 1962.

Plate 7, figures 12, 13

1958 Klukisporites pseudoreticulatus Couper, Palaeontographica B, 103, p. 138, pl. 19, figs. 8-10.

1962 Dictyotriletes pseudoreticulatus (Couper) Pocock, Palaeontographica B, 111, p. 41, pl. 3, figs. 46-47.

DESCRIPTION: Trilete; laesurae almost reaching equator; equatorial outline

rounded-triangular; sides convex to straight; proximal face flat and smooth except around equator where distal sculpture encroaches; distal face strongly convex, with clear foveo-reticulate sculpture; lumina from 3 to 5 microns wide and spaced 2 to 4 microns apart; muri flat.

SIZE RANGE: Equatorial diameter 30 to 60 microns.

DISTRIBUTION: Upper Jurassic to Lower Cretaceous. Common. Reported from the upper portion of the Vanguard Formation (Pocock, 1962) to the Grand Rapids Formation in western Canada; and from the Purbeck and the Wealden of England (Couper, 1958).

AFFINITY: According to Couper (1958), this species has affinities with the Jurassic schizaeaceous plants Klukia exilis, Stachypteris hallei etc.

REMARKS: Reticulatisporites can be distinguished from this genus by its high muri which project into an outer membrane.

Potonie (1955) mentions an error made by him in his earlier paper (1954, Geol. Jb. Vol. 69 p. 144), where he put down D. mediareticulatus instead of D. bireticulatus as the type species. However, he points out that he mentioned the correct name i.e., D. bireticulatus in the explanation for pl. 20, fig. 98 in the same paper. He rectified this error (1955 Palaeontographica B, 98, pp. 106, 107) and restored D. bireticulatus as the type species.

LOCALITY OF FIGURED SPECIMENS: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 7, Fig. 12. Depth 1781 to 1791 feet; Grand Rapids Formation.

Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 7, Fig. 13. Depth 3726 to 3736 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 7, Fig. 12. Slide No. Micro. 93; co-ord. 13.2/36.5.

Pl. 7, Fig. 13. Slide No. Micro. 33; co-ord. 10.5/47.8.

Genus Klukisporites Couper, 1958

1958 Klukisporites variegatus Couper, Palaeontographica B, 103, p. 137, pl. 19, figs. 6, 7, (type species).

DIAGNOSIS: Trilete; laesurae long, about $3/4$ of radius of spore, commissures raised, bordered by a margo; equatorial countour rounded-triangular; distal surface with foveolate, foveo-reticulate or incomplete foveolate pattern consisting of convolute anastomosing ridges; contact area of proximal surface has greatly reduced sculpture; exine thick.

Klukisporites sp.

Plate 8, figure 1

DESCRIPTION: Trilete; laesurae simple slits, about $3/4$ radius of spore, flanked by slightly raised lips; equatorial outline triangular with convex sides and rounded apices; proximal surface smooth except at the apices where the distal ornament passes on to it; distal surface ornamented with convolute anastomosing ridges about 4 microns high and 4 to 6 microns wide which in certain instances enclose an area 10 to 12 microns in diameter, creating an effect of discontinuous and degenerating coarse foveolate pattern; exine thick.

SIZE RANGE: Equatorial diameter 51 microns.

DISTRIBUTION: Middle Albian. Very rare. In central Alberta two specimens of this species were recorded from the uppermost portion of the Grand Rapids Formation.

REMARKS: This species has not been formally described as only two specimens were found.

The generic diagnosis has been slightly altered to include in this group some specimens showing incomplete foveolate pattern consisting of convolute and anastomosing ridges.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 8, fig. 1. Depth 1781 to 1791 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 8, fig. 1. Slide No. Micro. 122; co-ord. 6.4/45.

Genus Lygodioisporites (Potonie, 1951) emend.

1934 Sporites solidus Potonie, Arb. Inst. Palaeob. Petr. Brennsteine 4, p. 42, pl. 1, fig. 35.

1951 Lygodioisporites solidus (Potonie) Potonie, Palaeontographica B, 91, p. 144, pl. 20, figs. 12, 13, (type species, subsequent designation).

1953 Corrugatisporites solidus (Potonie) Thomson and Pflug, Palaeontographica B, 94, pl. 2, figs. 37, 38, 40-43.

EMENDED DIAGNOSIS: Trilete microspores, laesurae extending from $1/2$ to $4/5$ of the spore radius, equatorial outline triangular with strongly convex to nearly straight sides and well rounded apices, ornamentation consisting of irregularly arranged, coarse, intersecting rounded ridges with projecting tubercles running in radial or other directions, spherical verrucae which may be dense or sparse, or confluent tubercles.

Ornamentation is evenly distributed all over the spore surface and does not show any tendency towards concentration at the apices as in the case of the genus Trilobosporites. The tuberculate ridges do not run parallel to the equatorial margin as in the case of the genus Corrugatisporites.

Lygodioisporites is here formally emended to include spores with shorter laesurae also so that all the heavily ornamented species which are morphologically similar to the spores of Lygodium may be grouped under the genus Lygodioisporites.

These are characterized by a loosely attached and easily detachable ectexine.

Lygodioisporites sp. A

Plate 8, figure 2

DESCRIPTION: Trilete; laesurae simple slits, bordered by thick and wide lips, about 3 to 4 microns in width, narrowing towards the extremities, extending up to 1/2 of the spore radius; equatorial outline triangular with straight sides and broadly rounded apices; proximal surface slightly flat; distal surface convex; both surfaces ornamented with flat, sparsely distributed verrucae; ectexine with ornamentation torn off from some areas on the proximal surface revealing smooth endexine; exine double-layered, about 4 microns thick.

SIZE RANGE: Equatorial diameter 65 microns.

DISTRIBUTION: Middle Albian. Very rare. In central Alberta a single specimen of this species was recorded from the Wabiskaw Member.

REMARKS: This species has not been formally described as only one specimen assignable to it was found.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 8, fig. 2. Depth 2923 to 2932 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 8, fig. 2. Slide No. Micro. 200; co-ord. 11.2/39.5.

Lygodioisporites sp. B

Plate 8, figure 3

DESCRIPTION: Trilete; laesurae gaping, extending up to 2/3 of the spore

radius; equatorial outline triangular; sides straight; apices broadly rounded; exine of both the proximal and distal surfaces densely verrucate; diameter of the verrucae 3 to 4 microns; exine thick.

SIZE RANGE: Equatorial diameter 58 microns.

DISTRIBUTION: Middle Albian. Very rare. In central Alberta only a few specimens of this species were recorded from the Wabiskaw Member and the Grand Rapids Formation.

REMARKS: This species has not been formally described as only a few specimens assignable to it were found.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 8, fig. 3. Depth 2451 to 2460 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 8, fig. 3. Slide No. Micro. 176; co-ord. 11/39.

Genus Lygodiumsporites (Potonie, Thomson and Thiergart, 1950) emend.

- 1933 Punctatisporites adriennis Potonie and Gelletich, Sitz. Ber. Ges. Naturf. Freunde, Berlin, p. 521, pl. 2, fig. 14.
- 1950 Lygodiumsporites adriennis (Potonie and Gelletich) Potonie, Thomson and Thiergart, Geol. Jb., 65, p. 45, pl. A, fig. 7, pl. C, fig. 2.
- 1956 Lygodiumsporites adriennis (Potonie and Gelletich) emend. Potonie, Beih. Geol. Jb., 23, p. 19, pl. 1, fig. 11, (type species).
- 1959 Leiotriletes adriennis (Potonie and Gelletich) Krutzsch subfsp. adriennis, Geologie, Jg. 8, Beiheft 21-22, pp. 1-425.

EMENDED DIAGNOSIS: Trilete microspores, laesurae extending from 1/2 to 4/5 of the spore radius, equatorial outline rounded-triangular, apices broadly rounded, exine smooth to sub-granulose.

Potonie (1956) restricted this genus to include spores with laesurae shorter than 1/2 the spore radius. However, forms like mesozoicus Thiergart, 1949 (pl. 4/5,

fig. 9) and subspecies like pseudomaximus (Thomson and Pflug, 1955) Krutzsch, 1959 (see Kedves, 1961, pp. 112-114, pl. 3, figs. 3-6) with laesurae extending from $2/3$ to $4/5$ of the spore radius have already been created within the species adriennis. In these cases species adriennis was transferred to the genera Sporites or Leiotriletes which have wide generic circumscriptions. It is felt that the restriction by Potonie (1956) is not serving any useful purpose. Therefore, the generic circumscription of Lygodiumsporites has been emended here to include the spores with longer laesurae also, so that all the smooth to sub-granulose species which are morphologically similar to the spores of Lygodium may be grouped under the genus Lygodiumsporites.

Lygodiumsporites sp. A

Plate 8, figure 4

DESCRIPTION: Trilete; laesurae as slits, bordered by thickened lips about 3 microns wide on either side, narrowing towards the extremities, nearly reaching the equator; equatorial outline triangular with convex sides and broadly rounded apices; exine smooth; distal surface strongly convex; exine double-layered about 6 microns thick; colour dark brown.

SIZE RANGE: Equatorial diameter 60 microns.

DISTRIBUTION: Barremian? to Middle Albian. Very rare. In central Alberta only two specimens of this species were recorded, one from the Ellerslie Member, and the other from the Grand Rapids Formation.

REMARKS: Recently, Pocock (in press) has erected the organ-genus Lygoidites to include spores of a type morphologically similar to those found in some species of

Lygodium which do not have a concentration of ornamentation at the apices as in the case of genus Trilobosporites. The type species of the genus Lygoidites is "Lygoidites" punctatus (Delcourt and Sprumont, 1955) Pocock. This species was originally described as "Concavisporites" punctatus Delcourt and Sprumont, 1955. Recently, it has been transferred to the genus Cyathidites as "Cyathidites" punctatus (Delcourt and Sprumont) Delcourt et al., 1963. The most consistent features of this species are its concave sides, on the basis of which it was originally designated as "Concavisporites" punctatus. However, as this species does not have kyrtoles it does not come within the generic circumscription of the genus Concavisporites and must be transferred to another genus. Its transfer to the genus Cyathidites by Delcourt et al. (1963) does not appear to be justified because it does not have a psilate exine, and displays a distinct margo. It is felt that "Concavisporites" punctatus should be transferred to a genus which exclusively contains species with concave sides and sub-granulose to verrucose ornamentation. Therefore, the writer has transferred it to the emended form-genus Concavissimisporites as Concavissimisporites punctatus (Delcourt and Sprumont) n. comb.

The organ-genus Lygoidites Pocock (in press) has not been used in this work because its type species "Lygoidites" punctatus (Delcourt and Sprumont) Pocock, does not appear to belong to this genus.

Lygodiumsporites sp. A has not been formally described as only two specimens assignable to it were found.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 8, fig. 4. Depth 3010 to 3019 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 8, fig. 4. Slide No. Micro. 224; co-ord. 10/40.

Lygodiumsporites sp. B

Plate 8, figure 5

DESCRIPTION: Trilete; laesurae simple slits, nearly reaching the equator, with a hole at the raised extremity of each laesura; equatorial outline triangular with straight sides and broadly rounded apices; distal surface convex; exine very finely granulate; double-layered; 4 to 5 microns thick.

SIZE RANGE: Equatorial diameter 85 microns.

DISTRIBUTION: Middle Albian. Very rare. In central Alberta only a few specimens of this species were recorded from the Clearwater Formation and upper portion of the Grand Rapids Formation.

REMARKS: This species has not been formally described as only a few specimens assignable to it were found.

Lygodiumsporites sp. B is nearly identical with Sporites adriennis Potonie f. mesozoicus Thiergart, 1949, including the length of laesurae. However, Lygodiumsporites sp. B is larger in size.

It is also similar to Hymenophyllumsporites deltoidus Rouse, 1957 but the ribbon-like lists bordering the laesurae, which are diagnostic of the latter, are lacking.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 8, fig. 5. Depth 1816 to 1826 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 8, fig. 5.

Slide No. Micro. 124;

co-ord. 10.1/34.2.

Genus Neoraistrickia Potonie, 1956

- 1953 Trilites truncatus Cookson, Aust. J. Bot., vol. 1, no. 3, p. 471, pl. 2, fig. 36.
 1956 Neoraistrickia truncatus (Cookson) Potonie, Beih. Geol. Jb. 23, p. 34, pl. 3, fig. 32, (type species).

DIAGNOSIS: Trilete; laesurae reach equator; equatorial outline rounded-triangular; exine ornamented by not too densely distributed clavate spines, with broadened tips; spines relatively thinner than those present on genus Raistrickia.

Neoraistrickia? sp.

Plate 8, figures 6, 7

DESCRIPTION: Trilete; laesurae reaching equator; commissures raised, narrow; equatorial outline rounded-triangular; both proximal as well as distal exine ornamented sparsely by 0.5 micron thin and 3.5 microns long clavate spines; exine thin.

SIZE RANGE: Equatorial diameter (including spines) 42 microns.

DISTRIBUTION: Barremian? Very rare. In central Alberta a single specimen of this species was found close to the base of the Ellerslie Member.

REMARKS: This species has not been formally described as only one specimen assignable to it was found.

This specimen has not been placed in the genus Pilosporites, because it is ornamented with distinctly clavate spines. Pilosporites has pointed spines.

Compared with other forms described under genus Neoraistrickia, the specimen described above has very thin clavate spines. Therefore, its identification is doubtful.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 8, figs. 6, 7. Depth 3174 to 3179; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 8, figs. 6, 7. Slide No. Micro. 251; co-ord. 11/41.

FAMILY GLEICHENIACEAE

Genus Gleicheniidites Ross ex Delcourt and Sprumont, 1955

- 1949 Gleicheniidites senonicus Ross, Bull. Geol. Inst. Upsala 34, p. 31, pl. 1, figs. 3, 4, (type species).
 1955 Gleicheniidites senonicus Ross ex Delcourt and Sprumont, Mem. Soc. Belg. Geol. n. s. 4(5), p. 26 (designation of type and generic diagnosis).

DIAGNOSIS: Trilete; laesurae simple, reaching or almost reaching the equator; equatorial outline triangular; apices sharply arcuate; sides usually concave to straight; exine smooth.

Gleicheniidites senonicus Ross, 1949

Plate 8, figures 8, 9

- 1949 Gleicheniidites senonicus Ross, Bull. Geol. Inst. Upsala 34, p. 31, pl. 1, figs. 3, 4.
 1957 Gleichenia concavisporites Rouse, Can. J. Bot. 35, p. 363, pl. 2, figs. 36, 48, pl. 3, fig. 49.
 1961 Gleichenia senonica (Ross) Grigorjeva, Trans. of the All Union Petr. Sci. Res., Geol. Surv. Inst., vol. 17, p. 46, pl. 13, figs. 1a-b, 2a-b, 3a-b.

DESCRIPTION: Trilete; laesurae simple, reaching the equator; equatorial outline triangular; apices sharply arcuate; sides usually straight to concave; proximal face flat; distal face strongly convex; proximo-distal flattening resulting in three folds on the distal side, parallel to the outer margin of the spore; exine smooth,

1 micron or less thick.

SIZE RANGE: Equatorial diameter 20 to 38 microns.

DISTRIBUTION: Jurassic and Cretaceous. Abundant.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 8, fig. 8.	Depth 2815 to 2824 feet;	Clearwater Formation, Shale Member.
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Pl. 8, fig. 9.	Depth 2782 to 2785 feet;	Clearwater Formation, Shale Member.
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REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 8, fig. 8.	Slide No. Micro. 194;	co-ord. 12/40.
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Pl. 8, fig. 9.	Slide No. FA2782-2785-3;	co-ord. 20/51.6.
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Gleicheniidites cf. G. circinidites (Cookson) n. comb.

Plate 8, figures 10, 11

1953 Gleichenia circinidites Cookson, Aust. J. Bot., vol. 1, p. 464, pl. 1, figs. 5, 6.

1957 Gleichenia cf. G. circinidites Cookson in Balme, C.S.I.R., Australia, Coal Research Section, Reference T.C. 25, p. 23, pl. 3, figs. 42-44.

DESCRIPTION: Trilete; laesurae bordered by thin lips, reaching the equator; equatorial outline triangular; apices pointed and rhombic in shape; sides straight to slightly concave; proximal face flat; distal face strongly convex; proximo-distal compression of the tetrad results in inter-apical foldings characteristic of the spores in family Gleicheniaceae, the dark lines on plate 8, figure 11 perhaps represent a diffraction pattern related to the thickened zones.

SIZE RANGE: Equatorial diameter 27.5 microns.

DISTRIBUTION: Upper Jurassic to Lower Cretaceous and Eocene? Very rare.

In central Alberta this species was recorded from the Clearwater Formation and the Grand Rapids Formation. Gleichenia cf. G. circinidites described by Balme from

the Upper Jurassic and the Lower Cretaceous of Western Australia is very similar to this species. Gleichenia circinidites Cookson, 1953 is larger and occurs in the Eocene sediments in the Perth area.

REMARKS: Under a taxonomic approach which favours the use of natural genera these specimens would be placed under Gleichenia circinidites.

The specimen of Gleichenia cf. G. circinidites illustrated on pl. 3, fig. 42 by Balme (1957) is nearly identical with the Canadian specimens.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 8, figs. 10, 11. Depth 1781 to 1791 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 8, figs. 10, 11. Slide No. Micro. 102; co-ord. 11.7/39.8.

FAMILY CYATHEACEAE or DICKSONIACEAE

Genus Cyathidites Couper, 1953

1953 Cyathidites australis Couper, N.Z. Geol. Surv. Pal. Bull. 22, p. 27, pl. 2, fig. 11, (type species).

DIAGNOSIS: Trilete; laesurae simple, always over 2/3 of the radius of spore; equatorial outline triangular; apices broadly rounded; sides concave; proximal face is slightly convex whereas the distal face is markedly convex; exine psilate.

Cyathidites australis Couper, 1953

Plate 8, figure 12

1953 Cyathidites australis Couper, N.Z. Geol. Surv. Pal. Bull. 22, p. 27, pl. 2, fig. 11.

DESCRIPTION: Trilete; laesurae simple and long, almost reaching the equator;

equatorial outline triangular; apices broadly rounded; sides slightly concave; distal face convex; exine smooth, about 2 microns thick.

SIZE RANGE: Equatorial diameter 50 to 65 microns.

DISTRIBUTION: Jurassic and Lower Cretaceous. Rare.

REMARKS: The genus Cyathidites can be distinguished from Deltoidospora by its concave sides and thin exine. Deltoidospora has straight to slightly convex sides, and the exine is about 5 microns thick. Concavissimisporites can be distinguished from both by the presence of sub-granulose to verrucose exine ornamentation.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 8, fig. 12. Depth 1791 to 1801 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 8, fig. 12. Slide No. Micro. 137; co-ord. 11.1/43.

Cyathidites minor Couper, 1953

Plate 8, figure 13

1953 Cyathidites minor Couper, N.Z. Geol. Surv. Pal. Bull. 22, p. 28, pl. 2, fig. 13.

DESCRIPTION: Trilete; laesurae simple, over 3/4 of the radius of spore; equatorial outline triangular; apices broadly rounded; sides slightly concave; distal face convex; exine smooth, 1 to 2 microns thick.

SIZE RANGE: Equatorial diameter 25 to 45 microns.

DISTRIBUTION: Jurassic and Cretaceous. Abundant. The lower part of the Gravelbourg Formation to the Colorado Formation in western Canada (Pocock, 1962). Reported from the same horizon in New Zealand and England by Couper (1953, 1958).

AFFINITY: Couper (1958) who compared this species with the spores isolated

from the fertile specimens of Mesozoic species of Coniopteris hymenophylloides, Dicksonia mariopteris and other cyatheaceous or dicksoniaceous ferns found a close similarity between them.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 8, Fig. 13. Depth 1816 to 1826 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 8, Fig. 13. Slide No. Micro. 123; co-ord. 13.1/39.1.

FILICALES - INCERTAE SEDIS

Genus Trilobosporites (Pant, 1954 nom. nud.) ex Potonie, 1956

1955 Concavisporites hannonicus Delcourt and Sprumont, Mem. Soc. Belg. Geol. n. s. 4(5), p. 24, pl. 2, fig. 3.

1956 Trilobosporites hannonicus (Delcourt and Sprumont) Potonie, Beih. Geol. Jb. 23, p. 55, pl. 7, fig. 68, (type species, subsequent designation).

DIAGNOSIS: Trilete; equatorial outline triangular; sides more or less concave; apices rounded with thickened exine.

Trilobosporites hannonicus (Delcourt and Sprumont) Potonie, 1956

Plate 8, figures 14, 15

1955 Concavisporites hannonicus Delcourt and Sprumont, Mem. Soc. Belg. Geol. n. s. 4(5), p. 24, pl. 2, fig. 3.

1956 Trilobosporites hannonicus (Delcourt and Sprumont) Potonie, Beih. Geol. Jb. 23, p. 55, pl. 7, fig. 68.

DESCRIPTION: Trilete; laesurae reach about 3/4 of radius of spore; margo present on most specimens; equatorial outline triangular, with concave to straight sides; proximal face flat; distal face convex; exine double-layered with granular to verrucate ornamentation on both proximal and distal surfaces; the ectexine is thickened

on the rounded apices in the form of a cap, with verrucate surface.

SIZE RANGE: Equatorial diameter 60 to 75 microns.

DISTRIBUTION: Barremian? to Aptian? Common. This species was recorded from the uppermost portion of the Deville Member, in central Alberta. It was described from the "Wealden" of Belgium. However, the age of Belgian "Wealden" is uncertain, and has been provisionally placed in the Aptian Stage by Allen (1955).

REMARKS: Trilobosporites hannonicus looks very similar to the various species of genus Triquitrites from the Palaeozoic. However, the two can be distinguished fundamentally by the fact that in T. hannonicus there is only an ektexinal thickening in the form of a cap on the rounded apices without any protuberance, while in Triquitrites, the apices bear thickened protuberances which are distinct from the main body.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 8, fig. 14. Depth 3213 to 3222 feet; Deville Member.

Pl. 8, fig. 15. Depth 3222 to 3231 feet; Deville Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 8, fig. 14. Slide No. Micro. 257; co-ord. 10.8/43.5.

Pl. 8, fig. 15. Slide No. Micro. 256; co-ord. 10.2/40.2.

Trilobosporites apiverrucatus Couper, 1958

Plate 8, figures 16-18

1958 Trilobosporites apiverrucatus Couper, Palaeontographica B, 103, p. 142, pl. 21, fig. 11.

DESCRIPTION: Trilete; laesurae about $3/4$ of radius of spore; margo present on most specimens; equatorial outline triangular; sides strongly concave to straight; proximal face flat; distal face convex; polar ornamentation on both proximal and distal

surfaces is composed of only small verrucae; some specimens may have only a scabrate sculpture; apical ornamentation is always more pronounced with verrucae of about 5 microns in diameter on an average; in specimens of smaller size the apical ornamentation may be reduced to only a coarse granulation; in coarsely ornamented specimens, larger verrucae may sometimes border the margo; exine 2 to 3 microns thick, a little thicker at the apices.

SIZE RANGE: Equatorial diameter 35 to 90 microns.

DISTRIBUTION: Berriasian to Middle Albian. Abundant. In western Canada this species is found throughout the Mannville Group, though it is more abundant in the Lower Mannville. It makes its first appearance in the Fairlight Clay (Berriasian) in England (Couper, 1958).

AFFINITY: The affinity is not certain; although the thickened apices suggest a dicksoniaceous origin.

REMARKS: This species resembles Trilobosporites trioreticulosus Cookson and Dettmann, 1958 very closely, but can be distinguished from it as the latter has shallow lumina with polygonal muri on the apices instead of verrucae.

LOCALITY OF FIGURED SPECIMENS: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 8, fig. 16.	Depth 2085 to 2095 feet;	Wabiskaw Member.
Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).		
Pl. 8, fig. 17.	Depth 3726 to 3736 feet;	Ellerslie Member.
Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).		
Pl. 8, fig. 18.	Depth 2905 to 2914 feet;	Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 8, fig. 16.	Slide No. Micro. 89;	co-ord. 8.5/44.2.
Pl. 8, fig. 17.	Slide No. Micro. 32;	co-ord. 11.8/43.
Pl. 8, fig. 18.	Slide No. FA2905-2914-1;	co-ord. 0.8/61.2.

Trilobosporites canadensis Pocock, 1962

Plate 8, figures 19, 20

1962 Trilobosporites canadensis Pocock, Palaeontographica B, 111, p. 44, pl. 4, figs. 63-68.

DESCRIPTION: Trilete; laesurae simple, almost reaching equator; equatorial outline triangular; sides concave to straight; general surface strongly verrucose; verrucae arise from thick ectexine, average size 9 microns in diameter and 4.5 microns in height, very well rounded and dome-shaped; on the proximal face the verrucae are present in the apical areas, bordering the laesurae in a single line, and around the equator; on the distal face the verrucae are present in apical areas, in the centre of the face and around the equator; exine thick, ranging from 6 microns at the apices to 3 microns on the rest of the body.

SIZE RANGE: Equatorial diameter 45 to 75 microns.

DISTRIBUTION: Barremian? to Aptian. Rare. In western Canada this species makes its first appearance in the Deville Member and continues into the Ellerslie Member in lesser abundance, Pocock (1962). In central Alberta it is very rare in the Deville Member becoming common in the Ellerslie Member. The few specimens found in the Clearwater Formation are probably reworked.

REMARKS: The ornamentation in Trilobosporites canadensis is extremely variable. It may be very subdued, looking very similar to Trilobosporites bernissartensis (Delcourt and Sprumont) Potonie, or may be heavily ornamented with large bulbous verrucae covering the entire spore surface. The two grade into one another by intermediate forms.

LOCALITY OF FIGURED SPECIMENS: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 8, fig. 19.	Depth 3768 to 3778 feet;	Ellerslie Member.
Pl. 8, fig. 20.	Depth 3706 to 3716 feet;	Ellerslie Member.
REPOSITORY: Res. Coun. Alberta Palynological Type Coll.		
Pl. 8, fig. 19.	Slide No. Micro. 40;	co-ord. 9/51.
Pl. 8, fig. 20.	Slide No. Micro. 18;	co-ord. 17.5/38.2.

Trilobosporites trioreticulosus Cookson and Dettmann, 1958

Plate 9, figures 1, 2

- 1958 Trilobosporites trioreticulosus Cookson and Dettmann, Proc. Roy. Soc. Victoria, new ser., vol. 70, pt. 2, p. 109, pl. 17, figs. 1-3.
- 1961 Lygodium trioreticulosus (Cookson and Dettmann) Bolkhovitina, Acad. Sci. U.S.S.R., Trans. Geol. Inst., vol. 40, p. 100, pl. 35, figs. 5a-d, pl. 38, fig. 8.

DESCRIPTION: Trilete; equatorial outline triangular with broadly rounded apices and straight to slightly concave sides; laesurae about $\frac{3}{4}$ the radius of spore with usually thickened margo; the apices are ornamented with a shallow reticulum consisting of polygonal to rounded lumina and broad muri; exine is 2 to 3 microns thick, with scabrate surface.

SIZE RANGE: Equatorial diameter 55 to 80 microns.

DISTRIBUTION: Barremian? to Albian. Abundant. This species makes its first appearance in the Ellerslie Member, where it is abundant. It continues into the Upper Mannville strata. This species was first described from eastern Australia where it probably has an Aptian-Albian time range.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 9, fig. 1.	Depth 2983 to 2992 feet;	Calcareous Member.
Pl. 9, fig. 2.	Depth 2932 to 2938 feet;	Wabiskaw Member.
REPOSITORY: Res. Coun. Alberta Palynological Type Coll.		
Pl. 9, fig. 1.	Slide No. FA2983-2992-3;	co-ord. 19.8/71.8.
Pl. 9, fig. 2.	Slide No. Micro. 216;	co-ord. 12.9/42.9.

Trilobosporites minor Pocock, 1962

Plate 9, figure 3

- 1962 Trilobosporites minor Pocock, Palaeontographica B, 111, p. 44, pl. 4, figs. 61, 62.

DESCRIPTION: Trilete; laesurae about 1/2 of radius of spore, simple; equatorial outline triangular; sides straight to slightly concave; apices rounded; exine scabrate; apiculae concentrated at the apices on both proximal and distal faces, and also border the laesurae on either side.

SIZE RANGE: Equatorial diameter 30 to 40 microns.

DISTRIBUTION: Lower Cretaceous. Common. Present throughout the Mannville Group.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 9, Fig. 3. Depth 1816 to 1826 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 9, Fig. 3. Slide No. Micro. 119; co-ord. 17.1/45.9.

Genus Pilosisorites Delcourt and Sprumont, 1955

- 1949 Sporites trichopapillosus Thiergart, Palaeontographica B, 89, p. 22, pl. 4, 5, fig. 18.
- 1955 Pilosisorites trichopapillosus (Thiergart) Delcourt and Sprumont, Mem. Soc. Belg. Geol., n. s. 4(5), p. 34, pl. 3, fig. 3, (type species).
- 1961 Lygodium trichopapillosus (Thiergart) Bolkhovitina, Acad. Sci. U.S.S.R., Trans. Geol. Inst., vol. 40, p. 102, pl. 38, figs. 1a-b.

DIAGNOSIS: Trilete; laesurae do not reach the equator completely; equatorial contour triangular; sides slightly convex, straight or concave; ornamentation echinate; fimbriae, capilli or short thin spines cover all or large parts of the surface.

Pilosisorites trichopapillosus (Thiergart) Delcourt and Sprumont, 1955

Plate 9, figure 4

- 1949 Sporites trichopapillosus Thiergart, Palaeontographica B, 89, p. 22, pl. 4, 5, fig. 18.
- 1955 Pilosisorites trichopapillosus (Thiergart) Delcourt and Sprumont, Mem. Soc. Belg. Geol., n. s. 4(5), p. 34, pl. 3, fig. 3.
- 1961 Lygodium trichopapillosus (Thiergart) Bolkhovitina, Acad. Sci. U.S.S.R., Trans. Geol. Inst., vol. 40, p. 102, pl. 38, figs. 1a-b.

DESCRIPTION: Trilete; laesurae $3/4$ of radius of spore, bordered by margo; equatorial outline triangular; sides slightly convex to slightly concave; proximal surface flattened; distal surface strongly convex; ornamentation echinate; spines curved with sharp points, from 5 to 10 microns long, arising from an outer exine coat, there is a tendency in some specimens for the spines to be slightly more crowded at the apices; exine 3 to 4 microns thick.

SIZE RANGE: Equatorial diameter 50 to 85 microns.

DISTRIBUTION: Purbeck to Middle Albian. In western Canada this species makes its first appearance in the Deville Member and continues up to the top of the Mannville Group, with a reduced frequency in the Upper Mannville strata. In England it makes its first appearance in the Purbeck Stage and continues into the Wealden (Couper, 1958). Also reported from the "Wealden" of Belgium (Delcourt and Sprumont, 1955).

LOCALITY OF FIGURED SPECIMEN: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 9, fig. 4. Depth 3850 to 3860 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 9, fig. 4. Slide No. Micro. 79; co-ord. 14/49.

Pilosisorites verus Delcourt and Sprumont, 1955

Plate 9, figure 5

- 1955 Pilosporites verus Delcourt and Sprumont, Mem. Soc. Belg. Geol., n. s. 4(5), p. 35, pl. 4, fig. 1.
- 1961 Lygodium verus (Delcourt and Sprumont) Bolkhovitinina, Acad. Sci. U.S.S.R., Trans. Geol. Inst., vol. 40, p. 103, pl. 38, figs. 3a-b.

DESCRIPTION: Trilete; laesurae $3/4$ of radius of spore, bordered by margo; equatorial outline triangular; sides slightly concave to slightly convex; corners well rounded; proximal surface flattened; distal surface convex; spines concentrated in the apical areas only on both sides, from 5 to 10 microns long; inter-radial areas finely punctate on both proximal and distal surfaces; exine about 2 microns thick.

SIZE RANGE: Equatorial diameter 50 to 75 microns.

DISTRIBUTION: Lower Cretaceous. Rare. In western Canada this species makes its first appearance in the Deville Member, and continues into the Ellerslie Member. In the Upper Mannville it becomes exceedingly rare, and is probably derived from the Lower Mannville. This species was described for the first time from the Belgian "Wealden" by Delcourt and Sprumont (1955).

LOCALITY OF FIGURED SPECIMEN: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 9, fig. 5. Depth 3768 to 3778 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 9, fig. 5. Slide No. Micro. 270; co-ord. 12.5/41.5.

Genus Concavissimisporites (Delcourt and Sprumont, 1955) emend. Delcourt, Dettmann and Hughes, 1963

- 1955 Concavissimisporites verrucosus Delcourt and Sprumont, Mem. Soc. Belg. Geol., n. s. 4(5), p. 25, pl. 2, fig. 1, (type species).
- 1961 Lygodium verrucosus (Delcourt and Sprumont) Bolkhovitinina, Acad. Sci. U.S.S.R., Trans. Geol. Inst., vol. 40, p. 100, pl. 37, figs. 2a, b.
- 1961 Lygodium Swartz, Ivanova (pars) in Samoilovitch et al., Trans. of the All Union Petr. Sci. Res., Geol. Surv. Inst., vol. 177, p. 90.
- 1962 Concavisporites verrucosus (Delcourt and Sprumont) Pocock (pars), Palaeontographica B, 111, 1-3, p. 46, pl. 5, fig. 73.

DIAGNOSIS: Microspores trilete; outline triangular with concave to almost straight sides. Exine of uniform thickness (inclusive of sculpture), sub-granulose to verrucose, granules or verrucae more or less uniformly developed and evenly distributed over entire spore surface.

The generic diagnosis has been slightly emended here to include sub-granulose and granulose spores also.

Concavissimisporites punctatus (Delcourt and Sprumont) n. comb.

Plate 9, figures 6, 7

- 1955 Concavisporites punctatus Delcourt and Sprumont, Mem. Soc. Belg. Geol., n. s. 4(5), p. 25, pl. 1, fig. 8, pl. 2, fig. 2.
- 1955 Concavisporites baldurnensis Delcourt and Sprumont, Mem. Soc. Belg. Geol., n. s. 4(5), p. 24, pl. 1, figs. 7a, b.
- 1955 Cingulatisporites cavus Delcourt and Sprumont, Mem. Soc. Belg. Geol., n. s. 4(5), p. 38, fig. 8.
- 1958 Concavisporites punctatus Delcourt and Sprumont in Couper, Palaeontographica B, 103, p. 142, pl. 22, figs. 1-3.
- 1962 Concavisporites punctatus Delcourt and Sprumont in Pocock, Palaeontographica B, 111, 1-3, p. 46, pl. 5, fig. 72.
- 1963 Cyathidites punctatus (Delcourt and Sprumont) Delcourt et al., Palaeontology vol. 6, pt. 2, p. 283, pl. 42, figs. 1-4.
- In press Lygoidites punctatus (Delcourt and Sprumont) Pocock, Grana Palyn., vol. 5.

DESCRIPTION: Trilete; laesurae around $3/4$ radius of spore; a distinct margo borders the frequently gaping laesurae, narrowing sharply towards the ends; equatorial outline triangular; sides mostly concave, but occasionally straight; apices well rounded; indistinct sub-granulose ornamentation present on both proximal as well as distal surfaces, highly oxidized or badly preserved specimens have a surface with rather undulose appearance.

SIZE RANGE: Equatorial diameter 55 to 75 microns.

DISTRIBUTION: Berriasian to Aptian. Common. In western Canada this species makes its first appearance in the Deville Member, and continues up to the Calcareous Member progressively decreasing in frequency. In the Upper Mannville it becomes exceedingly rare. In England it makes its first appearance in the Berriasian Stage (Couper, 1958). First reported from the "Wealden" of Belgium by Delcourt and Sprumont (1955).

REMARKS: Originally the genus Concavissimisporites included spores with strongly concave ("concavissime") sides. Obviously, the degree of concavity of the sides cannot form the basis for a new genus as the sides usually vary from weakly to strongly concave within the same species. Uncompressed or inflated specimens often display strongly concave sides (see Delcourt et al., 1963, pl. 42, figs. 1-4) within the same species. As emended by Delcourt et al. (1963) Concavissimisporites now contains spores with concave to almost straight sides.

Concavisporites Pflug, 1953 can be distinguished from the genus Concavissimisporites by the presence of kyrtomes (= Tori, formed by an abruptly convex exine area surrounding the laesurae which is reduced by three arcuate folds in the proximal inter-radial regions on compressed spores) and by its more or less smooth surface. The synonymizing of the two above mentioned genera by Pocock (1962, p. 47) is, therefore, not considered to be justified. Delcourt and Sprumont (1955), Couper (1958) and Pocock (1962) erroneously assigned many species to the genus Concavisporites which did not have kyrtomes around the laesurae and often had verrucose surface. Margo or laesurate lips which these authors probably confused with kyrtomes, are actually oblique exposures of a slightly thickened exine adjoining the laesurae, and

undehisced or uncompressed spores do not show them. The margo does not result in arcuate folds in the proximal inter-radial regions, after compression of the spore. All the species of the genus Concavisporites illustrated by Pflug (1953) show these inter-radial arcuate folds on the proximal surface. They are all characterized by the presence of kyrtoles, and have smooth surface with concave sides. The granulose to verrucose specimens without kyrtoles erroneously assigned to Concavisporites should, therefore, be transferred to the newly emended genus Concavissimisporites.

It is felt that the genus Concavissimisporites should not be restricted to include only verrucose spores as proposed by Delcourt et al. (1963). The shape of the spore, the position, shape, length and number of the germinal apertures, the nature of the exine adjoining the laesurae, the pattern of ornamentation or the complete absence of it are far more reliable criteria for a sub-division at the generic level, than a mere change in the degree of ornamentation e.g. granulose to verrucose. In fact, the difference between a granulose and a verrucose ornamentation is entirely arbitrary. Originally, species with sub-granulose ornamentation e.g. "Concavisporites" sub-granulosus Couper, 1958 were placed in the same genus as strongly verrucose species e.g. "Concavisporites" variverrucatus Couper, 1958. Spores with concave sides and ornamentation varying from sub-granulose to verrucose appear to form a normal morphologic group, because the ornamentation is often gradational. Therefore, the generic diagnosis has been slightly emended here to include sub-granulose and granulose spores along with verrucose spores within the genus Concavissimisporites.

In the opinion of the writer, the transfer of "Concavisporites" punctatus to the genus Cyathidites by Delcourt et al. (1963) does not seem to be justified. From

the original illustrations (Delcourt and Sprumont, 1955, pl. 1, fig. 8 and pl. 2, fig. 2) and the subsequent illustrations (Couper, 1958, pl. 22, figs. 1-3) of "Concavisporites" punctatus it is evident that it is not psilate like Cyathidites. Couper's (1958, p. 142) remark that the exine is "not distinctly sculptured" does not mean that it is psilate, because he adds later on that the exine does have a "rather undulose appearance". The sculpture of this species is indeed faint and varies from sub-granulose to "undulose" depending upon the quality of preservation and the degree of oxidation. Probably some more specimens besides the holotype should have been examined to determine the range of variation within C. punctatus. The holotype illustrated by Delcourt and Sprumont (1955, pl. 1, fig. 8) clearly shows "undulose" surface. Canadian specimens are conspecific with the European specimens and in so far as neither have a psilate exine, their transfer to the genus Concavissimisporites would probably be more justified than to the genus Cyathidites.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 9, fig. 6.	Depth 2815 to 2824 feet;	Clearwater Formation, Shale Member.
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Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 9, fig. 7.	Depth 1781 to 1791 feet;	Grand Rapids Formation.
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REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 9, fig. 6.	Slide No. Micro. 197;	co-ord. 10.5/40.5.
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Pl. 9, fig. 7.	Slide No. Micro. 100;	co-ord. 14/37.1.
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Concavissimisporites parkinii (Pocock) n. comb.

Plate 9, figure 8

1962 Concavisporites parkinii Pocock, Palaeontographica B, 111, p. 46, pl. 4, fig. 71.

DESCRIPTION: Trilete; laesurae about 3/4 radius of spore; a weakly developed

margo may or may not be present; commissures are always raised; equatorial outline triangular; sides weakly to strongly concave; both proximal and distal surfaces uniformly sub-granulose; exine 4 microns thick.

SIZE RANGE: Equatorial diameter 55 to 85 microns.

DISTRIBUTION: Barremian? to Aptian. Common. In western Canada this species makes its first appearance in the Deville Member and continues into the Ellerslie Member. The few specimens found in the Upper Mannville strata are probably reworked.

LOCALITY OF FIGURED SPECIMEN: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 9, fig. 8. Depth 3850 to 3860 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 9, fig. 8. Slide No. Micro. 67; co-ord. 14.5/37.2.

Concavissimisporites variverrucatus (Couper) n. comb.

Plate 9, figures 9-11

1958 Concavisporites variverrucatus Couper, Palaeontographica B, 103, p. 142, pl. 22, figs. 4, 5.

1961 Lygodium variverrucatus (Couper) Bolkhovitina, Acad. Sci. U.S.S.R., Trans. Geol. Inst., vol. 40, p. 100, pl. 36, fig. 5.

DESCRIPTION: Trilete; laesurae about 3/4 radius of spore; margo is weakly developed; equatorial outline triangular; sides concave; apices well rounded; both proximal and distal surfaces ornamented with verrucae varying from 1.5 to 5 microns in diameter in different specimens and projecting up to 2 microns above the general surface; exine 2 to 4 microns thick.

SIZE RANGE: Equatorial diameter 40 to 70 microns.

DISTRIBUTION: Bajocian to Middle Albian. Abundant. In western Canada this

species makes its first appearance in the upper portion of the Vanguard Formation and continues up to the Grand Rapids Formation. In England it makes its first appearance in the Gristhorpe Beds (Bajocian) becoming more abundant in the Purbeck Stage and the Wealden Beds (Couper, 1958).

REMARKS: This species is variable in size, shape, and spacing of the verrucae. Specimens exceeding 70 microns in size were not encountered. C. variverrucatus is much smaller in size as compared with C. verrucosus (74 to 90 microns) and C. crassatus (78 microns).

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 9, figs. 9, 11. Depth 3093 to 3102 feet; Ellerslie Member.

Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 9, fig. 10. Depth 3686 to 3696 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 9, fig. 9. Slide No. Micro. 236; co-ord. 12.9/41.

Pl. 9, fig. 10. Slide No. Micro. 13; co-ord. 8/58.8.

Pl. 9, fig. 11. Slide No. Micro. 242; co-ord. 10.5/41.5.

Concavissimisporites sp.

Plate 9, figure 12

DESCRIPTION: Trilete; equatorial outline triangular; sides very concave, apices well rounded; the laesurae not extending to the margin of the equator; the spore wall is composed of two layers, a thin inner layer (endexine) and a thick outer layer (ektexine); both the proximal and distal surfaces have a rather undulose appearance.

SIZE RANGE: Equatorial diameter 44 microns.

Thickness of exine 5 microns.

DISTRIBUTION: Barremian? and Aptian. Very rare. In central Alberta this

species was recorded only from the Ellerslie Member.

REMARKS: This specimen could be an uncompressed or inflated spore belonging to C. punctatus. However, its wall appears to be too thick for its inclusion in that species.

This species has not been formally described as only one specimen was found.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21 W. 4th Mer.).

Pl. 9, fig. 12. Depth 3010 to 3019 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 9, fig. 12. Slide No. Micro. 225; co-ord. 11.2/39.2.

Genus Deltoidospora (Miner, 1935) Potonie, 1956

1935 Deltoidospora hallii Miner, Am. Mid. Nat., 16(4), p. 618, pl. 24, fig. 7.

1956 Deltoidospora hallii (Miner) Potonie, Beih. Geol. Jahrb., vol. 23, p. 13, pl. 1, fig. 1, (type species).

DIAGNOSIS: Trilete; laesurae simple, more than 2/3 of spore radius; equatorial outline triangular with rounded apices; sides mostly straight, but may be slightly concave to convex, exine smooth.

Deltoidospora hallii Miner, 1935

Plate 9, figures 13, 14

1935 Deltoidospora hallii Miner, Am. Mid. Nat., 16(4), p. 618, pl. 24, fig. 7.

DESCRIPTION: Trilete; laesurae simple, more than 2/3 of spore radius; equatorial outline triangular with rounded apices; sides mostly straight but may be slightly concave to convex; exine smooth and thin.

SIZE RANGE: Equatorial diameter 30 to 40 microns.

DISTRIBUTION: Mesozoic. Abundant.

AFFINITY: Miner (1935) proposed the genus Deltoidospora to accommodate the deltoid and sub-deltoid spores associated with ferns e.g. Cladophlebis, Laccopteris and Gleichenites. Most of the Mesozoic deltoid spores show close affinity with the recent fern families e.g. Cyatheaceae, Polypodiaceae, and Gleicheniaceae. It is, however, not yet possible to affiliate them with the modern genera of ferns with any degree of certainty. The form-genus Deltoidospora is, therefore, considered appropriate for all the above mentioned deltoid and sub-deltoid spores.

REMARKS: Deltoidospora is distinguished from the genus Cyathidites Couper, 1953, by its very thick exine (about 5 microns) and its deltoid shape with usually straight to slightly convex sides. Cyathidites has a thin exine and concave sides.

LOCALITY OF FIGURED SPECIMENS: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 9, fig. 13. Depth 3768 to 3778 feet; Ellerslie Member.

Pl. 9, fig. 14. Depth 3726 to 3736 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 9, fig. 13. Slide No. Micro. 42; co-ord. 4.2/45.5.

Pl. 9, fig. 14. Slide No. Micro. 30; co-ord. 6/48.

Deltoidospora psilostoma Rouse, 1959

Plate 9, figure 15

1959 Deltoidospora psilostoma Rouse, Micropaleontology 5(3), p. 311, pl. 12, figs. 7, 8.

DESCRIPTION: Trilete; laesurae simple, more than $\frac{2}{3}$ of spore radius, generally gaping; equatorial outline triangular, with well rounded apices; sides straight to slightly concave or convex; exine smooth to weakly punctate, 3 to 6 microns thick.

SIZE RANGE: Equatorial diameter 40 to 60 microns.

DISTRIBUTION: Bathonian to Upper Cretaceous. Abundant. Upper part of Gravelbourg to Colorado Formation in western Canada, (Pocock, 1962).

LOCALITY OF FIGURED SPECIMEN: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 9, fig. 15. Depth 3716 to 3726 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 9, fig. 15. Slide No. Micro. 25; co-ord. 3/36.

Deltoidospora junctum (Kara-Murza) n. comb.

Plate 9, figure 16

1956 Cibotium junctum Kara-Murza in Bolkhovitina, Acad. Sci. U.S.S.R., Trans. Inst. Geol., No. 2, p. 37, pl. 3, figs. 25a-e.

DESCRIPTION: Trilete; commissures raised and nearly reaching the equator, bordered by a margo about 1 micron wide on each side; equatorial outline of the spore deltoid with slightly concave sides; apices rounded to rhombic in shape; proximal exine smooth; distal exine has a thickening perpendicular to the apices along which the exine is folded on itself as illustrated in figure 9. Under low power these foldings on the distal side give the false impression of being partitions.

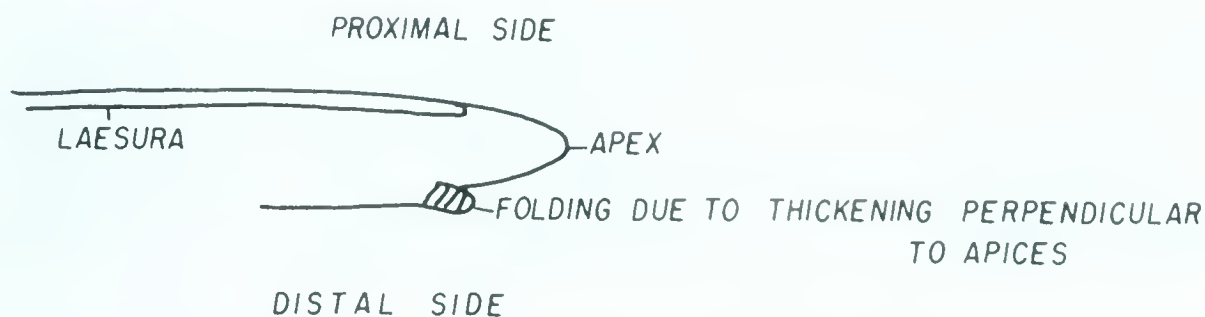


Figure 9. Deltoidospora junctum (Kara-Murza) n. comb.
A vertical section close to the apex.

SIZE RANGE: Equatorial diameter about 30 microns.

DISTRIBUTION: Upper Jurassic to Lower Cretaceous. Very rare. In central Alberta only a few specimens of this species were recorded from the Mannville Group. In Russia it ranges from the Upper Jurassic to Lower Cretaceous.

REMARKS: Under a taxonomic approach which favours the use of natural genera these specimens would be placed under Cibotium junctum.

The Canadian specimens seem to be identical with the specimen illustrated on plate 3, figure 25d by Bolkhovitina (1956). However, her interpretation of a "partition" perpendicular to the apices is probably wrong.

Tripartina paradoxiformis Maljavkina, 1956 (pl. 5, fig. 6) is also similar to Deltoidospora junctum, but it has not been described. The genus Tripartina Maljavkina, 1949 is not used here to accommodate D. junctum because so many different spore-forms have been placed in Tripartina by several authors, that it no longer appears to constitute a uniform unit. Neither the original nor the emended generic diagnosis of Tripartina by Potonie (1960) makes any reference to the foldings perpendicular to the apices. The form-genus Deltoidospora appears to be more suitable for the present species because of its deltoid shape, smooth exine and elongate laesurae.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 9, fig. 16. Depth 2496 to 2505 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 9, fig. 16. Slide No. Micro. 201; co-ord. 11.8/40.

Genus Hymenozonotriletes (Naumova, 1937) ex Naumova, 1953

1937 Hymenozonotriletes Naumova, Rep. 17th Sess. Internat. Geol. Congr., Abstr. Papers, U.S.S.R.

1953 Hymenozonotriletes polyacanthus Naumova, Trans. Inst. Geol. Sci., 143, Geol. Ser. (No. 60), p. 27, pl. 4, fig. 11, (type species).

DIAGNOSIS: Trilete microspores with a membranous zona; equatorial outline sub-triangular; exine covered with cones or spines.

Hymenozonotriletes mesozoicus Pocock, 1962

Plate 9, figures 17-19

1962 Hymenozonotriletes mesozoicus Pocock, Palaeontographica B, 111, 1-3, p. 49, pl. 5, figs. 85, 86.

DESCRIPTION: Trilete; zonate; laesurae over $2/3$ the radius of spore; commissures simple slits; equatorial outline triangular; sides convex; exine double-layered; smooth endexine overlain by ornamented ectexine which extends beyond the central body both distally and proximally, fusing to form a narrow, uniform, equatorial zona; three folds on the ectexine paralleling the laesurae and extending up to the margin of the zona on the proximal surface; proximal ectexine has only a few scattered short spines but the distal ectexine is scabrate bearing densely packed short spines near the pole, the spines becoming more sparse towards the equator; some of these spines are joined at their bases to form irregular ridges; zona thin, hyaline and altogether absent on some badly preserved specimens.

SIZE RANGE: Total equatorial diameter (including zona) 50 to 62 microns.

Equatorial diameter (excluding zona) 45 to 55 microns.

Width of zona 5 microns.

DISTRIBUTION: Barremian? and Aptian. Abundant at certain horizons. In western Canada this species is restricted to the Ellerslie Member. The few specimens found in the Upper Mannville strata are probably reworked from the Lower Mannville.

LOCALITY OF FIGURED SPECIMEN:: Fort Augustus No. 1 well (Lsd. 7,

Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 9, figs. 17-19. Depth 3093 to 3102 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 9, figs. 17-19. Slide No. Micro. 223; co-ord. 10.2/41.

Hymenozonotriletes pseudoalveolatus (Couper) n. comb.

Plate 10, figures 1-3

1958 Cingulatisporites pseudoalveolatus Couper, Palaeontographica B, 103, p. 147, pl. 25, figs. 5, 6.

DESCRIPTION: Trilete; zonate; laesurae reaching the inner margin of zona; commissures raised; equatorial outline rounded triangular; both proximal and distal surfaces bear short and thick papillae which may often be fused at the bases; the name pseudoalveolatus was given because the ornamentation in surface view appears as small pits; zona hyaline, narrow, delicate and rather irregular in outline.

SIZE RANGE: Total equatorial diameter (including zona) 55 microns.

Equatorial diameter (excluding zona) 44 microns.

Width of the zona 3.5 microns.

Spacing of the papillae 2 to 3 microns apart.

DISTRIBUTION: Bajocian to Middle Albian. Very rare. In central Alberta a single specimen of this species was recorded from the Grand Rapids Formation. In England it was recorded from the Bajocian to Aptian Stage, (Couper, 1958).

REMARKS: There are many instances where spores belonging to different morphological types, and bearing no resemblance to the type species, have been assigned to the genus Cingulatisporites. The generic diagnosis of Cingulatisporites, given by Pflug (1953) and Potonie (1956) has been ignored, and no distinction has been

made between the terms "zona" and "cingulum". A "cingulum" is a thickened equatorial rim, attached to a central body, the point of attachment being quite narrow; the cingulum and the central body being in the same equatorial plane. A "zona" on the other hand is hyaline, thin and is usually formed by the extension and fusion of the proximal and distal ectexine in the form of a flange around the equator of the spore. Cingulatisporites pseudoalveolatus Couper, 1958, is zonate and not cingulate. Moreover, its papillate surface is too heavily ornamented for the inclusion of this species in the genus Cingulatisporites which, according to its generic diagnosis, is "never strongly ornamented". Therefore, this species must be transferred to the genus Hymenozonotrilletes with whose generic description it is completely conformable.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 10, figs. 1-3. Depth 1921 to 1931 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 10, figs. 1-3. Slide No. Micro. 156; co-ord. 10.5/38.5.

Genus Couperisporites Pocock, 1962

1958 Cingulatisporites complexus Couper, Palaeontographica B, 103, p. 145, pl. 24, figs. 1, 2.

1962 Couperisporites complexus (Couper) Pocock, Palaeontographica B, 111, pp. 50, 51, pl. 6, figs. 91-94, (type species).

DIAGNOSIS: Trilete; rigid trilete mark reaching the zona and extending almost to the equatorial margin and sometimes bifurcating at the tips; proximal exine thin, smooth to granulate; distal surface of the central body with a narrow outer zone thickened with rugulate ornaments just inside the zona, and a wide inner area with polygonal based hollow bosses each carrying a short thick spine.

Couperisporites complexus (Couper) Pocock, 1962

Plate 10, figures 4-10

- 1958 Cingulatisporites complexus Couper, Palaeontographica B, 103, p. 145, pl. 24, figs. 1, 2.
- 1962 Couperisporites complexus (Couper) Pocock, Palaeontographica B, 111, pp. 50, 51, pl. 6, figs. 91-94.

DESCRIPTION: Trilete; laesurae reaching onto the zona and bifurcating, forming lips which merge laterally into the zona; commissures raised; equatorial outline rounded triangular; proximal exine thin, smooth to punctate; distal surface of the central body has an outer zone 5 to 8 microns wide thickened with rugulate ornament, just inside the zona and parallel to the equator; and a wide inner area which is completely covered with polygonal based hollow bosses about 5 microns wide at the base, each carrying a short solid spine about 3 microns long; zona is hyaline, 12 to 20 microns wide, ornamented with short thick spines about 3 microns broad and 2 microns high, spaced irregularly 5 to 10 microns apart.

SIZE RANGE: Equatorial diameter (including zona) 80 to 132 microns.

DISTRIBUTION: Barremian to Middle Albian. Common. In western Canada this species makes its first appearance in the Deville Member, and continues up to the top of the Mannville Group. In England this species makes its first appearance in the Barremian Stage (Hughes, 1958). An important stratigraphic marker.

REMARKS: The genus Couperisporites can be distinguished from Cirratriradites by the absence of distal polar thickenings and the radial ornaments. It differs from Cingulatisporites in that the zona is more than 1/5 of the spore diameter, the laesurae cross onto the zona, the ornamentation is heavier, and a zona rather than a cingulum surrounds the body.

LOCALITY OF FIGURED SPECIMENS: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 10, figs. 4, 8. Depth 1781 to 1791 feet; Grand Rapids Formation.

Pl. 10, figs. 5, 6, 7. Depth 1911 to 1921 feet; Grand Rapids Formation.

Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 10, figs. 9, 10. Depth 3850 to 3860 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 10, figs. 4, 8. Slide No. Micro. 73; co-ord. 10/37.8.

Pl. 10, figs. 5, 6, 7. Slide No. Micro. 155; co-ord. 11.5/39.

Pl. 10, figs. 9, 10. Slide No. Micro. 268; co-ord. 10/41.

Genus Staplinisporites Pocock, 1962

1957 Cingulatisporites caminus Balme, C.S.I.R., Australia, Ref. TC25, p. 27, pl. 5, figs. 62, 63.

1962 Staplinisporites caminus (Balme) Pocock, Palaeontographica B, 111, pp. 49, 50, pl. 5, 6, figs. 87-90, (type species).

DIAGNOSIS: Trilete; well developed raised commissures; equatorial outline rounded-triangular; proximal exine thin, smooth to granulose; distal surface ornamented by concentric and radial bands of exinal thickening, the distal pole carries a thickened granulose boss which may become detached leaving a thin granulose area.

Staplinisporites caminus (Balme) Pocock, 1962

Plate 11, figures 1-4

1957 Cingulatisporites caminus Balme, C.S.I.R., Australia, Ref. TC25, p. 27, pl. 5, figs. 62, 63.

1962 Staplinisporites caminus (Balme) Pocock, Palaeontographica B, 111, pp. 49, 50, pl. 5, 6, figs. 87-90.

DESCRIPTION: Trilete; laesurae reach the equator; commissures well developed and raised; equatorial outline rounded-triangular; proximal surface has thin, smooth to slightly granulose exine; distal surface is two-layered, with two concentric bands of thickened exine 2 to 3 microns wide, the outer band separates off a 5 microns wide

equatorial zone, while the inner band surrounds the distal pole separating off a circular area, these two bands are joined by radial bands, which also extend onto the equatorial zone; the distal pole possesses a granulose thickened boss, which may become detached leaving a thin granulose area exposed.

SIZE RANGE: Equatorial diameter 35 to 45 microns.

DISTRIBUTION: Upper Jurassic and Lower Cretaceous. Common. In central Alberta this species is abundant at certain horizons in the Deville and Ellerslie Members, and absent from the rest of the Mannville Group. Pocock (1962) reports it as rare in the upper parts of the Fernie and Vanguard Formations and continuing throughout the Mannville Group. In Western Australia it has been reported from the Oxfordian to Aptian Stages by Balme (1957).

REMARKS: Although the genus Staplinisporites closely resembles Cirratriradites, an examination under high power clearly indicates that the equatorial zone does not have the nature of a flange so characteristic in Cirratriradites. On the other hand, although Balme (1957) mentions in his description of Cingulatisporites caminus, that the laesurae extend only up to the junction of the central body and cingulum, his figured specimens (pl. 5, figs. 62, 63) show the laesurae reaching the equator. Insofar as the laesurae clearly extend onto the equatorial zone, these specimens cannot be included within the genus Cingulatisporites.

LOCALITY OF FIGURED SPECIMENS: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 11, fig. 1. Depth 3742 to 3743 feet; Ellerslie Member.

Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 11, figs. 2-4. Depth 3213 to 3222 feet; Deville Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 11, fig. 1. Slide No. Micro. 36; co-ord. 16.4/53.5.

Pl. 11, figs. 2-4 Slide No. Micro. 243; co-ord. 11.1/39.1.

Genus Taurocusporites Stover, 1962

1962 Taurocusporites segmentatus Stover, Micropaleontology, vol. 8, no. 1, p. 55, pl. 1, figs. 1-14, (type species).

DIAGNOSIS: Spores radial; trilete; equatorial outline convexly triangular to sub-circular. Proximal surface smooth or ornamented; distal surface trizonate. Trilete distinct; lips weakly developed to prominent, smooth or segmented.

Taurocusporites segmentatus Stover, 1962

Plate 11, figure 5

1962 Taurocusporites segmentatus Stover, Micropaleontology, vol. 8, no. 1, p. 55, pl. 1, figs. 1-14.

DESCRIPTION: Trilete; laesurae extend almost up to the equator and are always bounded by smooth or transversely segmented lips; equatorial outline convexly triangular to sub-circular with a smooth to slightly crenulate margin, which are in fact short radial cracks developed along the outer margin of the spore; distal surface unornamented and divided into three concentric areas (trizonate); the three relatively wide, thick, dark zones are separated from each other by two narrow, thin, light, more or less circular grooves, the outer groove being wider and more uniform in width compared with the inner one; the proximal surface is ornamented with low, irregularly shaped verrucae which are closely packed and form a negative reticulum; equatorial area is frequently unornamented; exine 2 to 4 microns thick at the equator, but is thinner over the unornamented parts and in the grooves.

SIZE RANGE: Equatorial diameter 40 to 50 microns.

Length of laesurae 20 microns.

Width of the lips 6 to 8 microns.

Width of the outer zone 6 to 9 microns.

Width of the middle zone 6 to 11 microns.

Diameter of the inner zone 10 to 17 microns.

DISTRIBUTION: Lower Cretaceous. Rare. In central Alberta, this species occurs throughout the Mannville Group. It was first described from the Lower Cretaceous of Maryland, U.S.A.

REMARKS: The erection of the new form-genus Taurocusporites Stover, 1962 appears to be justified insofar as it can be easily distinguished by its trizonate distal surface and a distinct trilete mark from Chomotriletes (Naumova, 1937) ex Naumova 1953, in spite of the fact that both possess circular concentric ridges and grooves. However, Stover's emendation of the genus Chomotriletes to include only alete spores, does not appear to be based on valid grounds, for reasons discussed earlier under that genus (p. 146). Thus, although Taurocusporites can be recognized as a new genus, some of the species of Chomotriletes described by Bolkhovitina, Lubert and Naumova should be retained in that genus.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 11, fig. 5. Depth 1816 to 1826 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 11, fig. 5. Slide No. Micro. 144; co-ord. 10.2/41.

Taurocusporites reduncus (Bolkhovitina) Stover, 1962

Plate 11, figure 6

1953 Chomotriletes reduncus Bolkhovitina, Acad. Sci. U.S.S.R., Geol. Sci. Proc., Issue 145, Geol. Ser. (no. 61), p. 35, pl. 3, figs. 23-24.

1962 Taurocusporites reduncus (Bolkhovitina) Stover, Micropaleo., vol. 8, no. 1, p. 57, pl. 1, figs. 15-21.

DESCRIPTION: Trilete; laesurae extend almost up to the equator but are faint; on most specimens the lips bordering the laesurae are absent, but in some cases they may be faintly developed; equatorial outline sub-circular with smooth to slightly crenulate margin; distal surface unornamented and divided into three concentric areas; the thickened zones are irregularly circular with many indentations, the zones may also have incomplete marginal thickening as shown on plate 11, figure 6; the proximal surface is unornamented, exine about 3 microns thick at the equator, but is reduced to less than one micron on the proximal surface.

SIZE RANGE: Equatorial diameter 36 to 46 microns.

Length of laesurae about 20 microns.

Width of outer zone about 7 microns.

Width of middle zone about 6 microns.

Diameter of inner zone about 12 microns.

DISTRIBUTION: Middle Jurassic to Upper Cretaceous. Rare. In central Alberta this species occurs throughout the Mannville Group. In other parts of the world it occurs in the Middle Jurassic of Pakistan, Denmark and Yakutiya region of U.S.S.R., the Lower Cretaceous of Maryland, U.S.A., the Lower Cretaceous (Aptian) and the Upper Cretaceous (Senonian) of western Kazakhstan, U.S.S.R.

REMARKS: Taurocusporites reduncus differs from T. segmentatus in the complete absence of the lips or only faintly developed unsegmented lips bordering the laesurae, and in an unornamented proximal surface. T. triangularis (Bolkhovitina) Stover, 1962 can be distinguished from T. reduncus by the presence of lips and

smooth, circular distal zones, which are distinct from the indented thickened ridges on the distal surface of T. reduncus.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 11, fig. 6. Depth 1816 to 1826 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 11, fig. 6. Slide No. Micro. 144; co-ord. 11.4/39.

Taurocusporites minor n. sp.

Plate 11, figures 7-11

DESCRIPTION: Trilete; laesurae extend almost up to the equator, and are bordered by a distinct, smooth, 1.5 microns wide lip on either side; equatorial outline convexly triangular to sub-circular with smooth margin; proximal surface flat and unornamented; distal surface convex, unornamented, and trizonate; the exine at the distal pole slightly thinner, surrounded by a cap-like area of darker and thicker exine on the margin of which there are small pits about 1 micron in diameter; between these pits radiate slightly thickened strips of exine; surrounding this thick cap-like zone is an area of thinner exine about 3 microns wide which in turn is surrounded by a thickened equatorial zone 3 microns wide.

SIZE RANGE: Equatorial diameter of holotype 27 microns.

Length of laesurae about 12 microns.

Width of lips about 1.5 microns each.

Width of the outer zone about 3 microns.

Width of the middle zone about 6 microns.

Diameter of the inner thin zone about 9 microns.

DISTRIBUTION: Barremian? to Middle Albian. Rare. In central Alberta this species has been recorded from the Ellerslie and Wabiskaw Members.

REMARKS: Taurocusporites minor n. sp. is a spore of trizonate and radial structure with a distinct trilete mark. It is conformable with the diagnosis given for the genus Taurocusporites by Stover (1962). T. minor n. sp. is close to T. reduncus which has indented thickened zones. However, T. minor n. sp. can be distinguished by its distinct trilete mark with wide lips, and the pits (instead of indentations) surrounding the second thickened zone.

This species is also very similar to Leiotriletes incertus Bolkhovitina, 1956 from which it can be distinguished only by its much smaller size. It is not clear why Bolkhovitina (1956) placed such distinctly trizonate forms as L. bujargiensis and L. incertus in the genus Leiotriletes. Although the descriptions as well as the illustrations by Bolkhovitina are very sketchy, it appears that perhaps both of these species should be transferred to the genus Taurocusporites Stover, 1962.

TYPE LOCALITY: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Holotype: Pl. 11, figs. 7-11. Depth 2923 to 2932 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 11, figs. 7-11. Slide No. FA2923-2932-3; co-ord. 9.8/36.1.

Genus Aequitriradites (Delcourt and Sprumont, 1955) emend.

Cookson and Dettmann, 1961

1955 Aequitriradites dubius Delcourt and Sprumont, Bull. Soc. Belg. Geol., n. s. 4(5), p. 45, pl. 3, fig. 7, (type species).

1961 Aequitriradites (Delcourt and Sprumont) emend. Cookson and Dettmann, Palaeontology, vol. 4, pt. 3, p. 426, pl. 52, figs. 1-12.

DIAGNOSIS: Trilete microspores with a membranous zona. Laesurae distinct

or only faintly represented especially towards the proximal pole. Exine entire or perforated distally. When perforated, the opening is formed as the result of a natural exinous breakdown about the distal pole. Sculptural elements various.

Aequitriradites spinulosus (Cookson and Dettmann)

Cookson and Dettmann, 1961

Plate 11, Figures 12, 13

- 1958 Cirratriradites spinulosus Cookson and Dettmann, Proc. Roy. Soc. Victoria, n. s. 70(2), p. 113, pl. 18, fig. 9.
- 1961 Aequitriradites spinulosus (Cookson and Dettmann) Cookson and Dettmann, Palaeontology, vol. 4, pt. 3, p. 426, pl. 52, figs. 1-12.
- 1961 Selaginellidites spinulosus (Cookson and Dettmann) Krasnova, Trans. of the All Union Petr. Sci. Res., Geol. Surv. Inst., vol. 177, p. 41, pl. 11, figs. 3a-b.

DESCRIPTION: Weakly trilete; laesurae variable in extent and prominence and may be absent altogether, in some specimens they are visible on the zona only, whereas in others they can be traced to within a short distance of the proximal pole; equatorial outline sub-triangular to sub-circular; central body surrounded by a membranous zona which overlaps the distal face for a short distance; proximal face smooth to faintly scabrate; distal face probably two-layered and ornamented with densely arranged spinules having polygonal bases, ranging in diameter from 1 to 4 microns, which become widely dispersed and smaller towards the equator of the central body; exine of the central body about 2 to 4 microns thick; zona membranous, scabrate, 5 to 15 microns wide.

SIZE RANGE: Equatorial diameter (including zona) 55 to 90 microns.

DISTRIBUTION: Cretaceous. Abundant. In western Canada this

species makes its first appearance in the Ellerslie Member, has high representation up to the Wabiskaw Member and continues up to the top of the Mannville Group in much reduced frequency. Also reported from the Lower Cretaceous of eastern Australia by Cookson and Dettmann (1958) and from the Lower and Upper Cretaceous of the Vilyui Basin of Russia by Bolkhovitina (1959). An important stratigraphic marker.

REMARKS: Aequitriradites spinulosus can be easily distinguished from A. variabilis as the latter has a very irregular outline, less dense ornamentation, generally indistinct laesurae, and a central body with circular outline.

Aequitriradites differs from Cirratriradites in the absence of foveae (a sculpture pattern which consists of thinner depressed areas of the exine surrounded by raised, thickened muri). Instead in some specimens of Aequitriradites an opening in the distal exine may be present. The radial ornamentation so characteristic of Cirratriradites is also absent in this species.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 11, fig. 12. Depth 3093 to 3102 feet; Ellerslie Member.

Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 11, fig. 13. Depth 1931 to 1941 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 11, fig. 12. Slide No. Micro. 237; co-ord. 11.9/38.1.

Pl. 11, fig. 13. Slide No. Micro. 157; co-ord. 12.5/41.

Aequitriradites variabilis Pocock, 1962

Plate 11, figures 14, 15

1962 Aequitriradites variabilis Pocock, Palaeontographica B, 111, pp.51, 52, pl. 6, figs. 98-100.

DESCRIPTION: Weakly trilete; laesurae indistinct, may be absent altogether,

when visible reaching on to the zona almost to the equator; equatorial outline generally very irregular, sometimes rounded-triangular; central body circular in equatorial section, and surrounded by a hyaline zona which overlaps the distal face by about 5 microns; proximal surface smooth to scabrate; distal surface probably two-layered, and ornamented with baculae 4 to 5 microns long, spaced about 5 microns apart; each bacula arises from a polygonal base, about 4 microns in diameter; rounded granules interspersed between the baculae; distal exine about 3 microns thick; zona hyaline, membranous, scabrate, with a few scattered granules; width of zona 8 to 18 microns.

SIZE RANGE: Equatorial diameter (including zona) 60 to 90 microns.

DISTRIBUTION: Barremian? to Middle Albian. Common. In western Canada this species makes its first appearance in the Ellerslie Member, and continues up to the top of the Mannville Group with reduced frequency. An important stratigraphic marker.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 11, fig. 14. Depth 2896 to 2905 feet; Wabiskaw Member.

Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 11, fig. 15. Depth 3716 to 3726 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 11, fig. 14. Slide No. Micro. 198; co-ord. 11.8/42.8.

Pl. 11, fig. 15. Slide No. Micro. 21; co-ord. 11.6/45.2.

Genus Rouseisporites Pocock, 1962

1962 Rouseisporites reticulatus Pocock, Palaeontographica B, 111, p. 53, pl. 7, figs. 101-105, (type species).

DIAGNOSIS: Alete or trilete; equatorial outline convexly triangular with narrow

equatorial flange which may be reduced to an apical flange in some species, laesurae indistinct and in some specimens may be absent altogether, when present they are terminated by extensions of the equatorial flange; in some species, the spore body has extensions only in the apical portions; apical extensions may be penetrated by holes which may or may not visibly penetrate the central body; some species have a Y-shaped distal ornamentation.

Rouseisporites reticulatus Pocock, 1961

Plate 11, figures 16, 17

1962 Rouseisporites reticulatus Pocock, Palaeontographica B, 111, p. 53, pl. 7, figs. 101-105.

DESCRIPTION: Trilete; laesurae faintly developed, reaching the equator, terminated by three holes penetrating the equatorial flange; equatorial outline rounded-triangular; equatorial flange about 5 microns wide on the sides and 8 microns at the apices; distal face convex, traversed by ridges 2 microns wide demarcating polygonal areas 14 to 22 microns in diameter, surface smooth; proximal face less convex, finely reticulate, ornamentation parallel to the laesurae and more distinct near it, being much reduced in the inter-radial areas, where it is only granulose.

SIZE RANGE: Equatorial diameter (including equatorial flange) 50 to 63 microns.

DISTRIBUTION: Barremian? to Albian. Common. In western Canada this species makes its first appearance in the Deville Member and continues into the Ellerslie Member where its frequency is high. It becomes extremely rare in the Clearwater Formation, but increases again in the Grand Rapids Formation. Cingulatisporites euskirchenoides Delcourt and Sprumont, 1955 with which Rouseisporites

reticulatus appears to be conspecific, makes its first appearance in the "Wealden" of Belgium, and in the Aptian-Albian of eastern Australia, Papua and New Guinea (Cookson and Dettmann, 1958).

AFFINITY: The apical holes indicate an affinity with the bryophyte genus Riccia.

REMARKS: This species appears to be conspecific with Cingulatisporites euskirchenoides Delcourt and Sprumont, 1955. However, the sketch drawn by Delcourt and Sprumont is entirely inadequate to confirm this similarity. Later illustrations of C. euskirchenoides (pl. 17, fig. 5) by Cookson and Dettmann (1958) clearly show the apical holes penetrating the equatorial flange, and seem to be identical with R. reticulatus, although no mention was made of these structures by the authors. It is obvious, that these forms do not agree with the generic circumscription of Cingulatisporites, and the erection of a new genus to accommodate them was necessary. The creation of the new species also seems to be justified in the absence of adequate illustrations and description for the holotype of C. euskirchenoides.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 11, fig. 16.	Depth 3037 to 3046 feet;	Ellerslie Member.
Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).		
Pl. 11, fig. 17.	Depth 1781 to 1791 feet;	Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 11, fig. 16.	Slide No. Micro. 231;	co-ord. 10.8/42.5.
Pl. 11, fig. 17.	Slide No. Micro. 94;	co-ord. 5.1/41.

Rouseisporites laevigatus Pocock, 1962

Plate 11, figure 18

DESCRIPTION: Alete; some specimens having a very faint trilete mark from the apices to the proximal pole; equatorial outline triangular; sides convex; apices moderately sharp; equatorial flange thin, widening at the apices, and with slight indications of a pore; exine scabrate on both sides; proximal face flat; distal face convex, with corrugate ridges radiating from the pole, progressively reduced towards the equator; perispore may or may not be present.

SIZE RANGE: Equatorial diameter 50 to 66 microns.

DISTRIBUTION: Barremian? to Albian. Rare. In western Canada this species makes its first appearance in the Ellerslie Member, is absent from the Clearwater Formation, but reappears again in the Grand Rapids Formation.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 11, fig. 18. Depth 1781 to 1791 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 11, fig. 18. Slide No. Micro. 101; co-ord. 13.5/45.

Rouseisporites triangularis Pocock, 1962

Plate 11, figure 19

1962 Rouseisporites triangularis Pocock, Palaeontographica B, 111, p. 54, pl. 7, figs. 110, 111.

DESCRIPTION: Trilete; laesurae faint, reaching up to $3/4$ of the radius of the spore, and terminating at the conical depression at the apices of the spore body; equatorial outline triangular; sides convex; apices moderately sharp; equatorial flange reduced, present as three conical structures 5 microns wide at the apices only; proximal exine scabrate; distal exine marked by a distinct Y-shaped ridge which alternates with the faint proximal trilete mark, the distal pole often has reticulate

ridges which are reduced to a scabrate structure radiating towards the equator.

SIZE RANGE: Equatorial diameter (including flanges at apex) 38 to 50 microns.

DISTRIBUTION: Barremian? to Albian. Rare. In western Canada this species makes its first appearance in the Ellerslie Member, and reappears again in the Grand Rapids Formation. Cingulatisporites simplex Cookson and Dettmann, 1958 with which this species seems to be conspecific, has been described from the Lower Cretaceous (Albian?) of eastern Australia.

REMARKS: As illustrated by Cookson and Dettmann (1958, pl. 17, fig. 7) Cingulatisporites simplex clearly shows the distal Y-shaped ridge alternating with the faint proximal trilete mark. The apical flanges appear to have been eroded. But the holotype (plate 17, fig. 8) does not show these features and the morphological interpretations drawn by the authors are entirely different. They consider the distal Y-shaped ridge to be the actual trilete mark. Therefore, no alterations would be justified without examining the actual specimens.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 11, fig. 19. Depth 3174 to 3179 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 11, fig. 19. Slide No. Micro. 252; co-ord. 10.4/42.4.

Genus Cooksonites Pocock, 1962

1962 Cooksonites variabilis Pocock, Palaeontographica B, 111, pp.54, 55, pl. 7, figs. 112-117, (type species).

DIAGNOSIS: Alete or rarely trilete; exine thick, usually internally striate, covering the entire proximal surface of the central body, extending to the distal surface beyond the equator and thinning over an approximately circular area

surrounding the distal pole.

Cooksonites variabilis Pocock, 1962

Plate 12, figures 1-3

1962 Cooksonites variabilis Pocock, Palaeontographica B, 111, pp. 54, 55, pl. 7, figs. 112-117.

DESCRIPTION: Alete or rarely trilete; laesurae $1/2$ the radius of spore, simple; equatorial outline oval to sub-circular or sub-triangular; exine two-layered; a patella (the thick outer exine layer) covers the entire proximal surface of the central body and extends to the distal surface, it is thinner over the proximal pole and thicker at the equator; bands of differential thickening across the proximal face may be present occasionally; the patella is smooth, and partly covers the distal surface; the central body is exposed over an approximately circular area surrounding the distal pole which is ornamented by a meshwork of polygonal plates; equatorial thickness of the patella is 8 to 12 microns and the thickness at the proximal pole is 4 to 5 microns; the diameter of the distal exposed area 35 to 40 microns; spore colour dark brown.

SIZE RANGE: Equatorial diameter 60 to 70 microns.

DISTRIBUTION: Barremian? and Aptian. Common. Abundant at certain horizons. In western Canada this species makes its first appearance in the Deville Member and continues into the Ellerslie Member where it is abundant. It reappears in the Grand Rapids Formation in much reduced frequency, probably as a result of reworking from the Lower Mannville beds.

REMARKS: The genus Cooksonites differs from Knoxisporites in that the patella encloses the proximal and not the distal surface, and in lacking the triradiate

thickened bands on the distal surface. It differs from Tholisporites in that the patella encloses the proximal and not the distal surface.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 12, fig. 1. Depth 3174 to 3179 feet; Ellerslie Member.

Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 12, figs. 2, 3. Depth 1911 to 1921 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 12, fig. 1. Slide No. Micro. 254; co-ord. 10.9/42.

Pl. 12, figs. 2, 3. Slide No. IW1911-1921-5; co-ord. 16.4/67.9.

Cooksonites reticulatus Pocock, 1962

Plate 12, figures 4-7

1962 Cooksonites reticulatus Pocock, Palaeontographica B, 111, pp. 55, 56, pl. 8, figs. 118-120.

DESCRIPTION: Alete; equatorial outline rounded-triangular; exine is about 15 microns thick, and the two layers are indistinguishable; exine internally and radially striate; around the distal pole a circular area of 30 to 40 microns has a thinner exine and is raised above the surface of the spore as a low dome; the exine on the proximal surface is ornamented by a network of pits connected by fine grooves, this type of ornamentation also extends onto the thick distal exine bordering the thin domed distal polar zone, over which the ornamentation is reticulate with very thin muri and lumina about 3 microns in diameter; apiculae are often developed where the muri join; near the outer margin of the dome the ornamentation is less pronounced; spore colour is dark orange-brown.

SIZE RANGE: Equatorial diameter 55 to 72 microns.

DISTRIBUTION: Barremian? and Aptian. Common at certain horizons. In

western Canada this species makes its first appearance in the Ellerslie Member where it is quite common. In the Grand Rapids Formation it is extremely rare and may be reworked from the Lower Mannville beds.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 12, figs. 4-7. Depth 3010 to 3019 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 12, figs. 4-7. Slide No. Micro. 226; co-ord. 12.5/42.

Genus Januasporites (Pocock, 1962) emend.

1962 Januasporites reticularis Pocock, Palaeontographica B, 111, p. 56, pl. 8, figs. 121-123, (type species).

EMENDED DIAGNOSIS: Alete microspores; often showing the rudiments of a non-functional tetrad scar on the ectexine of the proximal contact zone; exine two-layered; ectexine thin, absent over a more or less circular area on the distal face, the endexine is also thin in this circular area; ectexine forms a narrow hyaline zona around the central body; equatorial outline rounded-triangular; endexine smooth to scabrate; both proximal and distal ectexine have either a reticulate, corrugate or spinose ornamentation.

Januasporites spiniferus n. sp.

Plate 12, figures 8-12

DESCRIPTION: Alete microspores; equatorial outline rounded-triangular, most specimens show the rudiments of a non-functional, faint tetrad scar on the ectexine of the proximal contact zone; exine two-layered, endexine thick and smooth; ectexine thin, absent over a more or less circular area averaging 28 microns in diameter on

the distal face; endexine is also thin in this circular zone which perhaps represents the distal germinal area; ectexine forms a 2 to 5 microns wide hyaline zona around the central body; both proximal and distal ectexine ornamented with hyaline spines about 4 to 8 microns long, and 0.2 to 2 microns wide, very variable in shape, and often broadening at the tips; distribution of the spines sparse.

SIZE RANGE: Equatorial diameter (total) 55 to 60 microns.

Equatorial diameter of the holotype (total) 57.4 microns.

DISTRIBUTION: Middle Albian. Common. In central Alberta this species is abundant at certain horizons in the Grand Rapids Formation. It is an important stratigraphic marker restricted to the Upper Mannville strata.

REMARKS: This genus has been emended with the consent of the original author. When Pocock (1962) erected the genus Januasporites he could not determine the range of variation within this genus because he had only one species. Since then, more detailed observations on both tetrads and single spores during the present study have made certain alterations in the generic diagnosis necessary. Januasporites encompasses spores with a two-layered exine, with the ectexine being quite loose and hyaline, and with a more or less circular thin area on the distal face.

TYPE LOCALITY: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Holotype: Pl. 12, fig. 8. Depth 2496 to 2505 feet; Grand Rapids Formation.
Pl. 12, figs. 9-12. Depth 2496 to 2505 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 12, fig. 8. Slide No. Micro. 126; co-ord. 12.2/37.
Pl. 12, fig. 9. Slide No. Micro. 126; co-ord. 12/38.
Pl. 12, fig. 10. Slide No. Micro. 239; co-ord. 8.5/43.2.
Pl. 12, fig. 11. Slide No. Micro. 238; co-ord. 11/46.
Pl. 12, fig. 12. Slide No. Micro. 238; co-ord. 11.2/48.1.

- 1932 Sporonites verrucosus Ibrahim, in Potonie, Ibrahim and Klaus, p. 448, pl. 15, fig. 17.
- 1933 Verrucosi-sporites verrucosus Ibrahim, p. 25, pl. 2, fig. 17.
- 1954 Verrucosisporites verrucosus (Ibrahim) Potonie and Kremp, *Palaeontographica* B, 98, p. 69, pl. 13, fig. 196, (type species).

DIAGNOSIS: Trilete; circular to sub-circular in equatorial outline; exine covered with thickly crowded broad based warts which are more or less irregularly rounded or sometimes arcuate.

Verrucosisporites asymmetricus (Cookson and Dettmann) Pocock, 1962

Plate 13, figures 1, 2

- 1958 Apiculatisporites asymmetricus Cookson and Dettmann, *Proc. Roy. Soc. Victoria*, n. s. 70(2), p. 100, pl. 14, fig. 11.
- 1962 Verrucosisporites asymmetricus (Cookson and Dettmann) Pocock, *Palaeontographica* B, 111, p. 56, pl. 8, figs. 124-126.

DESCRIPTION: Trilete; laesurae indistinct, over 2/3 of radius of spore; equatorial outline variable, sub-triangular to sub-circular; sides invariably convex; exine about 2 to 3 microns thick, ornamented on both the distal and proximal surfaces by irregularly shaped, flat topped verrucae with an average diameter of 1.5 microns and a height of less than 1 micron.

SIZE RANGE: Equatorial diameter 35 to 60 microns.

DISTRIBUTION: Barremian? to Albian. Rare. In western Canada this species makes its first appearance in the Ellerslie Member where it is common. It reappears in the Grand Rapids Formation in much reduced frequency. It has been reported from the Albian Stage of eastern Australia by Cookson and Dettmann (1958).

REMARKS: The genus Verrucosisporites differs from Apiculatisporis Potonie and Kremp, 1956 in that it is not entirely circular and does not have tapered cones

as ornamentation. It differs from Granulatisporites in that the warts are not so small and spherical in shape. Converrucosisporites differs from it in having a triangular to sub-triangular outline.

The genus Apiculatisporites Ibrahim, 1933 has now been merged with Tuberculatisporites Ibrahim, 1932. Ibrahim included megaspores as well as microspores in his genus Apiculatisporites. He designated a megaspore Triletes VI Bennie and Kidston as the type species for Apiculatisporites. Subsequently it was found that Triletes VI belonged to the genus Tuberculatisporites. Therefore, Apiculatisporites was included in the genus Tuberculatisporites (according to the International Code of Botanical Nomenclature the generic name is attached with its type species). For the remaining species of the genus that thus lost their name a new generic name Apiculatisporis Potonie and Kremp, 1956 was proposed. However, specimens of Apiculatisporites figured by Cookson and Dettmann are closer to Verrucosisporites in character and were, therefore, transferred to it by Pocock (1962).

LOCALITY OF FIGURED SPECIMENS: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 13, fig. 1. Depth 1781 to 1791 feet; Grand Rapids Formation.

Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 13, fig. 2. Depth 3093 to 3102 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 13, fig. 1. Slide No. IW1781-1791-1; co-ord. 18.9/30.9.

Pl. 13, fig. 1. Slide No. FA3093-3102-1; co-ord. 9.8/57.

Verrucosisporites rotundus n. sp.

Plate 13, figure 3

DESCRIPTION: Trilete; laesurae simple slits, about $\frac{2}{3}$ of the radius of spore; equatorial outline nearly circular; proximal surface slightly convex; distal

surface markedly convex; both proximal and distal surfaces ornamented by flat and rounded verrucae ranging from 2 to 5 microns in diameter, densely packed, reaching up to the laesurae; exine thick; colour yellowish brown.

SIZE RANGE: Equatorial diameter 45 to 50 microns.

Equatorial diameter of the holotype 46 microns.

DISTRIBUTION: Barremian? and Aptian. Rare. In central Alberta a few specimens of this species were found in the Ellerslie Member.

REMARKS: This species has been placed in the genus Verrucosisporites, because of its nearly circular outline. Converrucosisporites has triangular to sub-triangular outline. Verrucosisporites rotundus n. sp. can be distinguished from Verrucosisporites obscurilaesurata Pocock, 1962 by its more distinct laesurae, and by regular, rounded verrucae of smaller size. It differs from Lygodioisporites perruacatus Couper, 1958 in having a much smaller size.

TYPE LOCALITY: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Holotype: Pl. 13, fig. 3. Depth 3742 to 3743 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 13, fig. 3. Slide No. Micro. 37; co-ord. 11/38.

Verrucosisporites sp.

Plate 13, figure 4

DESCRIPTION: Trilete; laesurae indistinct, about 2/3 the radius of spore; equatorial outline rounded-triangular; margin uneven; distal surface convex; both proximal and distal surfaces ornamented by flat and irregular-shaped verrucae 2 to 6 microns in diameter, densely packed, spaced about 0.5 microns apart; colour yellow-brown.

SIZE RANGE: Equatorial diameter 51 microns.

DISTRIBUTION: Middle Albian. Very rare. In central Alberta only a few specimens of this species were found near the base of the Clearwater Formation.

REMARKS: This species is similar to Verrucosisporites obscurilaesuratus Pocock, 1962, but the size of the verrucae is distinctly larger, and the equatorial outline is uniformly rounded-triangular.

This species has not been formally described as only a few specimens assignable to it were found.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21 W. 4th Mer.).

Pl. 13, fig. 4. Depth 2860 to 2869 feet; Clearwater Formation,
Shale Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 13, fig. 4. Slide No. Micro. 205; co-ord. 11.2/42.

Genus Microreticulatisporites (Knox 1950) Potonie and Kremp, 1954

- 1933 Reticulati-sporites lacunosus Ibrahim, Sporenformen des Aegirhorizonts, p. 36, pl. 6, fig. 50.
- 1950 Microreticulati-sporites lacunosus (Ibrahim) Knox, Trans. Bot. Soc. Edinb., p. 320, pl. 18, fig. 240.
- 1954 Microreticulatisporites lacunosus (Knox) Potonie and Kremp, Palaeontographica B, 98, p. 96, figs. 24, 25, (type species).

DIAGNOSIS: Trilete; equatorial outline triangular to circular; margin crenate to undulating; exine extrareticulate with small lumina whose diameters are not more than 6 microns, the muri are sometimes imperfect, branched, and of variable height.

Microreticulatisporites uniformis n. sp.

Plate 13, figures 5-7

- 1962 Microreticulatisporites sp. A Pocock, Palaeontographica B, 111, p. 57, pl. 8, fig. 128.

DESCRIPTION: Trilete; laesurae more than $3/4$ of spore radius; equatorial outline triangular; sides slightly convex to straight; margin crenate; apices rounded; distal surface ornamented by regular reticulate pattern which passes onto the proximal surface also for a short distance; most of the proximal surface smooth; lumina 2 to 3 microns in diameter; muri 1 to 2 microns in width.

SIZE RANGE: Equatorial diameter 44 to 48 microns.

DISTRIBUTION: Barremian? to Middle Albian. Common. In western Canada this species makes its first appearance in the Ellerslie Member, (Pocock, 1962) and continues up to the Grand Rapids Formation.

AFFINITY: This genus may have affinities with Noeggerathiales according to Potonie (1955).

REMARKS: Microreticulatisporites uniformis represents the formal description of Microreticulatisporites sp. A by Pocock (1962) who found only one specimen of this species and, therefore, did not give a formal description.

The genus Microreticulatisporites was revised and restricted by Potonie and Kremp (1954). They provided it with a type species which Knox (1950) had failed to designate, and excluded monolete forms, and certain other forms which belonged to other genera.

TYPE LOCALITY: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Holotype: Pl. 13, fig. 5.	Depth 1781 to 1791 feet;	Grand Rapids Formation.
Pl. 13, fig. 6.	Depth 1791 to 1801 feet;	Grand Rapids Formation.
Pl. 13, fig. 7.	Depth 1826 to 1836 feet;	Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 13, fig. 5.	Slide No. Micro. 99;	co-ord. 10.9/38.9.
Pl. 13, fig. 6.	Slide No. IW1791-1801-3;	co-ord. 6.5/53.
Pl. 13, fig. 7.	Slide No. IW1826-1836-3;	co-ord. 19.9/36.2.

Genus Granulatisporites (Ibrahim, 1933) Potonie and Kremp, 1954

- 1933 Granulatisporites granulatus Ibrahim, Sporenformen des Aegirhorizonts des Ruhr-Reviere (Berlin, Univ. doct. diss.) Wurzburg, 47 pp., pl. 6, fig. 51, (type species).
 1954 Granulatisporites granulatus (Ibrahim) Potonie and Kremp, Palaeontographica B, 98, pp. 56, 57, pl. 12, figs. 157-160.

DIAGNOSIS: Trilete; sub-triangular; exine densely granulose; granules rather spherical and of approximately equal size overall.

Granulatisporites sp.

Plate 13, figure 8

DESCRIPTION: Trilete; commissures raised, nearly reaching the equator; equatorial outline triangular with strongly convex sides; both distal and proximal exine densely granulose, granules spherical and about 1 micron in diameter, distal surface convex.

SIZE RANGE: Equatorial diameter 30 microns.

DISTRIBUTION: Barremian? to Middle Albian. Rare. In central Alberta only a few specimens were found in the Deville Member and the Clearwater Formation.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 13, fig. 8. Depth 2782 to 2785 feet; Clearwater Formation, Shale Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 13, fig. 8. Slide No. FA2782-2785-1; co-ord. 0.2/50.5.

Genus Laevigatosporites (Ibrahim, 1933) emend. Schopf, Wilson and Bentall, 1944

- 1932 Sporonites vulgaris Ibrahim in Potonie, Ibrahim and Loose, Neues Jahrb. Beilage-Band 67, Abt. B, p. 448, pl. 15, fig. 16.

- 1933 Laevigato-sporites vulgaris (Ibrahim) Ibrahim, Sporenformen des Aegirhorizonts des Ruhr-Reviere: Dissertation, Berlin, pp. 39-40, pl. 2, fig. 16, (type species).
 1934 Laevigato-sporites vulgaris forma major Loose, Inst. Palaobot. Arb., vol. 4, no. 3, p. 158, pl. 7, fig. 12.
 1950 Laevigato-sporites ovalis Kosanke, State Geol. Surv. Bull. No. 74, Illinois, U.S.A., p. 29, pl. 5, fig. 7.

DIAGNOSIS: Monolete; outline smooth; laevigate to infrapunctate; equatorial outline ovoid; meridional outline bean-shaped, exine always without sculpture; monolete mark straight.

Laevigatosporites ovatus Wilson and Webster, 1946

Plate 13, figures 9-11

- 1946 Laevigatosporites ovatus Wilson and Webster, Am. J. Bot., 33(4), pp. 271-278.
 1957 Laevigatosporites ovatus Wilson and Webster in Rouse, Can. J. Bot., 35, pp. 349-375.

DESCRIPTION: Monolete; suture straight, about 1/2 of spore length, mostly gaping; outline kidney-shaped; exine smooth, 1 micron thick; a thin perispore may be present.

SIZE RANGE: Length 34 to 55 microns. Breadth 22 to 35 microns.

Length to breadth ratio (average) 1.5.

DISTRIBUTION: Upper Jurassic and Cretaceous. Abundant.

AFFINITY: The smaller sized species of Laevigatosporites are very similar to forms obtained from filicinean type fructifications. Forms 50 microns in length have been referred to Calamariaceae by Fredda Reed (1938, p. 333). However, the monolete bean-shaped form indicates a close affinity with the families Polypodiaceae and the Dennstaedtiaceae.

LOCALITY OF FIGURED SPECIMENS: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

- Pl. 13, figs. 9, 11. Depth 3768 to 3778 feet; Ellerslie Member.
 Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Pl. 13, fig. 10. Depth 1781 to 1791 feet; Grand Rapids Formation.
 REPOSITORY: Res. Coun. Alberta Palynological Type Coll.
 Pl. 13, fig. 9. Slide No. Micro. 75; co-ord. 13/39.5.
 Pl. 13, fig. 10. Slide No. Micro. 112; co-ord. 16/39.
 Pl. 13, fig. 11. Slide No. Micro. 75; co-ord. 13/39.5.

Genus Dictyotosporites Cookson and Dettmann, 1958

- 1958 Dictyotosporites speciosus Cookson and Dettmann, Proc. Roy. Soc. Victoria, New Ser., vol. 70, pt. 2, p. 107, pl. 16, figs. 11-16, pl. 18, fig. 1, (type species).

DIAGNOSIS: Trilete microspores; laesurae inconspicuous before opening; laesurae reaching or almost reaching the margin; exine ornamented on both surfaces by a reticulate membrane, consisting of a primary reticulum and one or more superimposed reticula.

Dictyotosporites cf. D. speciosus Cookson and Dettmann, 1958

Plate 13, figures 12, 13.

- 1958 Dictyotosporites speciosus Cookson and Dettmann, Proc. Roy. Soc. Victoria, New Ser., vol. 70, pt. 2, p. 107, pl. 16, figs. 11-16, pl. 18, fig. 1.

DESCRIPTION: Trilete; laesurae extending up to equator, bordered by thin lips, equatorial outline rounded-triangular; proximal surface flat; distal surface strongly convex; exine about 5 microns thick; reticulation pattern indistinct, however, some muri can be seen arising from the surface which form the marginal membraneous network, muri about 3 microns high.

SIZE RANGE: Equatorial diameter 36 microns.

DISTRIBUTION: Neocomian to Middle Albian. Very rare. In central Alberta

a single specimen of this species was recorded from the base of the Wabiskaw Member. This species has been described from the Neocomian and Aptian Stages of eastern Australia.

REMARKS: Dictyotosporites cf. D. speciosus cannot be linked with the species originally described by Cookson and Dettmann (1958) with any degree of certainty. It is slightly smaller, with a more continuous rather than ragged outer lace-like zone. The reticulate pattern is also not distinctly visible.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 13, figs. 12, 13. Depth 2938 to 2947 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 13, figs. 12, 13. Slide No. FA2938-2947-2; co-ord. 5/59.8.

Genus Schizosporis Cookson and Dettmann, 1959

1959 Schizosporis reticulatus Cookson and Dettmann, Micropaleo., vol. 5, no. 2, pp. 213, 214, pl. 1, figs. 1-2, (type species).

DIAGNOSIS: Microspores medium to large, with an equatorial line or furrow along which a separation into two approximately equal parts takes place.

Schizosporis reticulatus Cookson and Dettmann, 1959

Plate 13, figure 14

1959 Schizosporis reticulatus Cookson and Dettmann, Micropaleo., vol. 5, no. 2, pp. 213, 214, pl. 1, figs. 1-4.

DESCRIPTION: Spore biconvex, flattened at the poles; circular in polar view; elliptical in equatorial view; splits equatorially into two nearly equal parts; exine thick, reticulate, with muri 1 micron wide, lumina mostly 6 sided, 8 to 10 microns in diameter.

SIZE RANGE: Equatorial diameter 102 microns. Ranging from 90 to 135 microns (Cookson and Dettmann, 1959).

DISTRIBUTION: Neocomian to Albian and Cenomanian? Very rare. In western Canada this species has been recorded from the Deville Member to the Grand Rapids Formation. It was first described from the Neocomian-Aptian to? Cenomanian Stages of eastern Australia.

REMARKS: The specimens recorded from the Mannville Group were few and badly preserved. The two layers of exine could not be detected. However, on the basis of the hexagonal muri, biconvex nature and the size range, these specimens can be classified in Schizosporis reticulatus.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 13, fig. 14. Depth 2442 to 2451 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 13, fig. 14. Slide No. Micro. 170; co-ord. 10/36.9.

Schizosporis parvus Cookson and Dettmann, 1959

Plate 13, figure 15

1959 Schizosporis parvus Cookson and Dettmann, Micropaleo., vol. 5, no. 2, p. 216, pl. 1, figs. 15-20.

DESCRIPTION: Spore elliptical in both equatorial and polar views; splitting equatorially into two elongate, boat-shaped equal halves; exine smooth, two-layered, most of the specimens have corroded surface and are badly preserved.

SIZE RANGE: Equatorial diameter (length) about 90 microns. Ranging from 65 to 90 microns (Cookson and Dettmann, 1959).

Polar diameter (width) about 60 microns. Ranging from 35 to 50 microns (Cookson and Dettmann, 1959).

DISTRIBUTION: Barremian? to Albian and Cenomanian? Very rare. In western Canada this species has been recorded from the Deville Member to the Grand Rapids Formation. It was first described from the Albian and? Cenomanian Stages of eastern Australia.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 13, fig. 15. Depth 2505 to 2514 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 13, fig. 15. Slide No. Micro. 178; co-ord. 11.5/40.

Schizosporis regulatus Cookson and Dettmann, 1959

Plate 13, figure 16

1959 Schizosporis regulatus Cookson and Dettmann, Micropaleo., vol. 5, no. 2, p. 216, pl. 1, figs. 5-9.

DESCRIPTION: Spore circular in polar view, biconvex in equatorial view, flattened at the poles; splits equatorially into two equal saucer-shaped sections; exine double-layered; ectexine ornamented with sinuous ridges which may unite to form a small-meshed, shallow reticulum.

SIZE RANGE: Equatorial diameter about 78.2 microns. Ranging from 82 to 112 microns (Cookson and Dettmann, 1959).

DISTRIBUTION: Barremian? to Albian and Cenomanian? Very rare. In western Canada this species has been recorded from the Ellerslie and Calcareous Members (Pocock, 1962) and the Grand Rapids Formation. It was first described from the Albian and? Cenomanian Stages of eastern Australia.

REMARKS: The Canadian specimens have a smaller average size (Pocock, 1962), but in other respects they are identical with the Australian specimens.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 13, fig. 16. Depth 1781 to 1791 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 13, fig. 16. Slide No. Micro. 104; co-ord. 9.3/39.1.

FAMILY CAYTONIACEAE

Genus Vitreisporites (Leschik, 1955) Jansonius 1962

1955 Vitreisporites signatus Leschik, Schweiz. Palaont. Abh., p. 53, pl. 8, fig. 10, (type species).

1962 Vitreisporites (Leschik) Jansonius, Palaeontographica B, 110, p. 55.

DIAGNOSIS: Bisaccate; central body oval in polar view; longer than broad; bladders finely reticulate and proximally attached at equator; distally reaching almost to distal pole, leaving only a straight narrow germinal area; overall size usually less than 35 microns; bladders large in relation to central body.

Vitreisporites pallidus (Reissinger) Nilsson, 1958

Plate 14, figure 1

1938 Pityosporites pallidus Reissinger, Palaeontographica B, 84, p. 14.

1950 Pityopollenites pallidus Reissinger, Palaeontographica B, 90, p. 109, pl. 15, figs. 1-5.

1955 Pollen of Masculostrobis E'Carp. in Delcourt and Sprumont, Mem. Soc. Belg. Geol., n. s. 5, p. 51, pl. 1, fig. 6.

1958 Caytonipollenites pallidus (Reissinger) Couper, Palaeontographica B, 103, pp. 149-150, pl. 26, figs. 7, 8.

1958 Vitreisporites pallidus (Reissinger) Nilsson, Pub. Inst. Min. Pal. and Quaternary Geol., Univ. Lund., No. 53, pp. 77-78.

DESCRIPTION: Bisaccate; central body oval in polar view; longer than broad; exine less than 1 micron thin; bladders finely reticulate and proximally attached at

equator; a distal sulcus can be seen on some specimens; bladders large in relation to central body.

SIZE RANGE: Total breadth of grain 20 (31) 40 microns.

Breadth of central body 6 (9) 12 microns.

Length of central body 12 (17) 20 microns.

Breadth of bladders 7 (12) 18 microns.

Length of bladders 12 (17) 20 microns.

DISTRIBUTION: Jurassic and Cretaceous. Very abundant.

AFFINITY: Indistinguishable from the pollen grains of Caytonanthus. Has strong affinity with the family Caytoniaceae.

REMARKS: The genus Vitreisporites was emended by Jansonius (1962) because the faint trilete mark mentioned by Leschik (1955) in the original diagnosis of this genus is in fact not present. Also, the restriction of the size of the central body to less than 20 microns by Leschik is not always true. Jansonius has given a more accurate and detailed generic diagnosis. Pityopollenites was considered invalid because Reissinger (1950) gave no generic diagnosis. Caytonipollenites Couper, 1958 is a junior synonym of Vitreisporites Leschik, 1955.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 14, fig. 1. Depth 1816 to 1826 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 14, fig. 1. Slide No. Micro. 118; co-ord. 14.1/37.5.

CYCADALES and/or BENNETTITALES

Genus Cycadopites (Wodehouse, 1933) ex Wilson and Webster, 1946

- 1933 Cycadopites Wodehouse, Bull. Torrey Bot. Club, 60, p. 483, fig. 56, Wisconsin.
- 1946 Cycadopites follicularis Wilson and Webster, Amer. J. Bot., vol. 33, no. 4, p. 274, fig. 7, (type species designated by Potonie, 1958).

DIAGNOSIS: Monosulcate pollen grains of more or less spindle-form shape; sulcus extending the total length of grain and broadening at the longitudinal ends; sulcus usually closed in the middle by furrow edges overlapping in shrinkage.

Cycadopites fragilis n. sp.

Plate 14, figure 2

- 1962 Monosulcites minimus Cookson in Pocock, Palaeontographica, 111, p. 77, pl. 13, figs. 206-208.

DESCRIPTION: Monosulcate pollen grains; sulcus broad; furrow edges rarely overlapping in middle; sulcus extending the whole length of the grain, and broadening at the longitudinal ends; outline fusiform; exine smooth, thin and fragile; lips 6 microns wide.

SIZE RANGE: Length 29 to 38 microns. Holotype 33 microns.

Breadth 15 to 26 microns. Holotype 20 microns.

Length to breadth ratio 1.4 (1.6) 2.0.

DISTRIBUTION: Jurassic and Cretaceous. Common. In central Alberta this species occurs throughout the Mannville Group.

AFFINITY: Shows distinct affinity with the cycadophytes.

REMARKS: Monosulcites has an oval to sub-circular boat-like shape. Unlike Cycadopites its sulcus has maximum width in the middle and is narrower and closed at the longitudinal ends. On this basis, the specimens illustrated by Pocock (1962) clearly belong to the genus Cycadopites.

It is felt that the synonym list for genus Cycadopites given by Jansonius (1962) would make this genus too broad to be of any stratigraphic use. Although Cycadopites as a group is quite monotonous and lacks distinguishing features, the various genera distinguished by Potonie (1958) under his Subturma Intortes (Naumova, 1937) Potonie, 1958 should stand. The general shape, exine ornamentation, length to breadth ratio and the shape of the sulcus should enable a meaningful subdivision of the monosulcate pollen.

TYPE LOCALITY: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Holotype: Pl. 14, fig. 2. Depth 1816 to 1826 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 14, fig. 2. Slide No. Micro. 117; co-ord. 12/40.8.

Cycadopites carpentieri (Delcourt and Sprumont) n. comb.

Plate 14, figure 3

1955 Monosulcites carpentieri Delcourt and Sprumont, Mem. Soc. Belg. Geol. n. s. 4(5), p. 54, fig. 14.

DESCRIPTION: Monosulcate; sulcus running entire length of grain, broadening at the longitudinal ends; grains long and narrow in polar view; exine smooth, about 1 micron thick.

SIZE RANGE: Length about 53 microns.

Breadth about 19 microns.

Length to breadth ratio (average) 2.8.

DISTRIBUTION: Middle Jurassic to Lower Cretaceous. Very rare. In central Alberta only a few specimens of this species were recorded from the Mannville Group. Couper (1958) recorded it from Middle Jurassic to Lower Cretaceous of England.

AFFINITY: This species closely resembles the pollen of Williamsonia spectabilis Nathorst, 1909 and appears to have a bennettitalean affinity (Couper, 1958).

REMARKS: Although the sketches of Monosulcites carpentieri made by Delcourt and Sprumont (1955) are not suitable for a close comparison, the present specimens agree fairly well with the illustrations of this species by Couper (1958). It is also very close to Entylissa deterius Balme, 1957 with which it may be conspecific.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 14, fig. 3. Depth 2905 to 2914 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 14, fig. 3. Slide No. FA2905-2914-3; co-ord. 18.6/40.5.

Cycadopites formosus n. sp.

Plate 14, figures 4, 5

DESCRIPTION: Monosulcate; sulcus running entire length of grain; furrow edges mostly overlapping in the middle, broadening at the longitudinal ends; grains wide in polar view; exine smooth, about 2 microns thick; lips 6 to 12 microns wide.

SIZE RANGE: Length 50 to 65 microns. Holotype 52 microns.

Breadth 30 to 45 microns. Holotype 34 microns.

Length to breadth ratio (average) 1.45.

DISTRIBUTION: Barremian? to Middle Albian. Common. In central Alberta this species occurs throughout the Mannville Group.

REMARKS: Cycadopites formosus is wider and larger in size than Cycadopites follicularis (Wilson and Webster, 1946) emend. Rouse, 1959.

TYPE LOCALITY: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Holotype: Pl. 14, fig. 4. Depth 2689 to 2699 feet; Clearwater Formation,
Shale Member.

Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
Pl. 14, fig. 5. Depth 2040 to 2042.5 feet; Clearwater Formation,
Shale Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 14, fig. 4. Slide No. Micro. 182; co-ord. 10/37.8.
Pl. 14, fig. 5. Slide No. Micro. 158; co-ord. 11/41.

Cycadopites sp.

Plate 14, figure 6

DESCRIPTION: Monosulcate; sulcus running entire length of grain; furrow edges only slightly overlapping in the middle; sulcus widening at the longitudinal ends; exine very faintly granulose; width about 1/2 the length, size very large, lips 24 to 28 microns wide.

SIZE RANGE: Length 104 microns.

Breadth 57 microns.

Length to breadth ratio 1.82.

DISTRIBUTION: Barremian? to Middle Albian. Very rare. In central Alberta a few specimens of this species were found in the Ellerslie and Wabiskaw Members.

REMARKS: This species has not been formally described as only a few specimens assignable to it were found.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 14, fig. 6. Depth 2932 to 2938 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 14, fig. 6. Slide No. Micro. 220; co-ord. 10.2/38.9.

Genus Bennettiteapollenites (Thiergart, 1949) Potonie, 1958

1949 Bennettiteapollenites lucifer Thiergart, Palaeontographica B, 89, p. 10, pl. 3, fig. 5, pl. 10, fig. 114, (type species).

DIAGNOSIS: Outline oval; width about $2/3$ the length of the grain; exine smooth; exine has three folds along the long axis which do not reach the margin, of these, two folds are close to one another while the third one is on the opposite side.

Bennettiteapollenites minimus n. sp.

Plate 14, figure 7

DESCRIPTION: Outline oval; width only slightly less than the length of the grain; exine smooth; distance between the proximal folds about 6 microns, width of the folds about 2 microns; exine has three folds along the long axis which do not reach the margin, of these, two folds are close to one another while the third one is on the opposite side.

SIZE RANGE: Length 25 to 30 microns. Holotype 27.2 microns.

Width 20 to 23 microns. Holotype 22 microns.

DISTRIBUTION: Barremian? to Middle Albian. Rare. In central Alberta this species was recorded throughout the Mannville Group.

AFFINITY: Has a bennettitalean affinity.

TYPE LOCALITY: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Holotype: Pl. 14, fig. 7. Depth 1951 to 1961 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 14, fig. 7. Slide No. IW1951-1961-1; co-ord. 16.2/54.

Bennettiteaepollenites sp.

Plate 14, figure 8

DESCRIPTION: Outline elongated oval; width only about 1/2 the length of the grain; exine smooth; distance between the proximal folds about 2 microns; width of the folds 6 to 8 microns; exine has three folds along the long axis which do not reach the margin, of these, two folds are close to one another while the third one is on the opposite side.

SIZE RANGE: Length about 82 microns.

Width about 40 microns.

DISTRIBUTION: Barremian? Rare. In central Alberta one specimen of this species was found near the base of the Ellerslie Member.

REMARKS: This species has been placed in the genus Bennettiteaepollenites provisionally because its width is only about 1/2 the length of the grain, whereas, according to the generic diagnosis it should be about 2/3 of the length. However, other features such as the distribution and structure of the folds are the same as for the genus Bennettiteaepollenites.

LOCALITY OF FIGURED SPECIMEN: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 14, fig. 8. Depth 3850 to 3860 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 14, fig. 8. Slide No. Micro. 78; co-ord. 7.8/39.

CONIFERALES

Genus Perinopollenites Couper, 1958

1958 Perinopollenites elatoides Couper, Palaeontographica B, 103, p. 152, pl. 27, figs. 9-11, (type species).

DIAGNOSIS: Monoporate; pore not always clearly shown, grains originally

more or less spherical, folding readily; exine consisting of two distinct layers, the outer loosely fitting.

Perinopollenites elatoides Couper, 1958

Plate 14, figure 9

1958 Perinopollenites elatoides Couper, Palaeontographica B, 103, p. 152, pl. 27, figs. 9-11.

DESCRIPTION: Monoporate; pore not always clearly shown; equatorial outline circular; a loosely fitting, thin and scabrate perispore which wrinkles and tears easily, surrounds the central body; central body is slightly thicker, smooth to scabrate.

SIZE RANGE: Total equatorial diameter including perispore 48 microns.

Ranges from 38 to 50 microns (Pocock, 1962).

Equatorial diameter of the central body excluding perispore

30 microns. Ranges from 28 to 36 microns (Pocock, 1962).

DISTRIBUTION: Jurassic and Lower Cretaceous. Very rare.

AFFINITY: These are probably the pollen of Elatides williamsonii, which belongs to family Taxodiaceae (Couper, 1958).

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 14, fig. 8. Depth 3174 to 3179 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 14, fig. 8. Slide No. Micro. 253; co-ord. 12.2/39.5.

Genus Alisporites (Daugherty, 1941) restr. Potonie & Kremp, 1956

1941 Alisporites opii Daugherty, Carnegie Inst., Washington, Publ. No. 526, p. 98, pl. 34, fig. 2, (type species).

- 1956 Alisporites opii (Daugherty) restr. Potonie and Kremp, Palaeontographica B, 99, pp.176-177, fig. 82.
- 1959 Alisporites Daugherty, emend. Rouse, Micropalaeontology 5(3), p. 314, pl. 1, figs. 10-16.

DIAGNOSIS: Bisaccate pollen without trilete mark; equatorial outline including sacci circular to oval; on the distal side there is a furrow with parallel sides which is not covered by the bladders; the length of the central body is the same as that of the bladders; central body not clearly defined; the sacci are thin, reticulate and very slightly distally pendant.

Alisporites cf. A. microsaccus (Couper) Pocock, 1962

Plate 14, figure 10

- 1958 Pteruchipollenites microsaccus Couper, Palaeontographica B, 103, p. 151, pl. 26, fig. 13.
- 1962 Alisporites cf. A. microsaccus Pocock, Palaeontographica B, 111, p. 61, pl. 9, figs. 138-139.

DESCRIPTION: Bisaccate; central body ill-defined, longer than broad; bladders poorly developed, longer than broad resulting in a circular outline in equatorial view; reticulum on bladders is about 1.5 microns in diameter; bladders slightly distally pendant covering most of the distal face, leaving only a narrow parallel-sided ill-defined distal furrow; bladders merge into a proximal cap with scabrate exine.

SIZE RANGE: Total breadth of grain 43 (70) 85 microns.

Breadth of central body 35 (55) 68 microns.

Length of central body 50 (70) 90 microns.

Breadth of bladders 20 (35) 48 microns.

Length of bladders 43 (70) 88 microns.

Width of distal furrow 5 (8) 12 microns.

DISTRIBUTION: Upper Jurassic and Lower Cretaceous. Rare.

AFFINITY: The genus Alisporites has probable affinities with the family Pinaceae (Rouse, 1959).

REMARKS: On the given description and illustrations, the genus Pteruchipollenites Couper, 1958 can scarcely be distinguished from many already described bisaccate genera. Pteruchipollenites microsaccus Couper, 1958 is easily covered by the generic characters of Alisporites, although its size range is smaller in comparison to Alisporites microsaccus.

The original diagnosis of the genus Alisporites by Daugherty (1941) was not very precise, therefore, Potonie and Kremp (1956) and Potonie (1958a) restricted this genus and gave a more precise diagnosis which has been followed in this work. Rouse (1959) emended Alisporites, in which he proposed: "Alisporites should be limited in reference to fossil pollen grains with two air bladders diametrically opposed in general pinaceous habit, but which do not have the bladders inclined distally or obviously attached to a central body as in the grains of the Pinaceae and Podocarpaceae". However, a closer examination of better preserved specimens do show an ill-defined central body, and an equatorial view of a grain shows slightly distally pendant bladders. In his diagnosis Rouse mentions: "two bladders diametrically opposed, united in the region of the proximal furrow", but the interpretation of Potonie (1958a) appears to be more accurate. Following the general morphological pattern of bisaccate pollen, he interprets the furrow to be distal, the parallel sides of which mark the bladder bases. The bladders are not united in the region of furrow, on the contrary, it marks an area where the central body is not covered by the bladders.

A well marked parallel-sided distal furrow or leptoma (= tenuitas) and only slightly distally pendant bladders distinguish the genus Alisporites from Pityosporites.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21 W. 4th Mer.).

Pl. 14, fig. 10. Depth 3036 to 3046 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 14, fig. 10. Slide No. Micro. 230; co-ord. 11.5/40.5.

Alisporites thomasii (Couper) Pocock, 1962

Plate 14, figures 11, 12

1958 Pteruchipollenites thomasii Couper, Palaeontographica B, 103, p. 150, pl. 26, figs. 10-12.

1959 Alisporites bilateralis Rouse, Micropaleontology, 5(3), p. 316, pl. 1, figs. 10, 11.

1962 Alisporites thomasii (Couper) Pocock, Palaeontographica B, 111, p. 62, pl. 9, figs. 142-144.

DESCRIPTION: Bisaccate; central body ill-defined, longer than broad to more or less circular in equatorial section; bladders well developed and of the same size as the central body giving the whole grain a smooth, oval shape; proximal cap thick; bladders slightly distally pendant, well developed; the bladder bases marked distinctly by a narrow parallel distal furrow; exine thin-walled, finely reticulate.

SIZE RANGE: Total breadth of grain 47 (60) 74 microns.

Breadth of central body 28 (34) 42 microns.

Length of central body 37 (44) 55 microns.

Breadth of bladders 15 (25) 35 microns.

Length of bladders 35 (45) 55 microns.

Width of distal furrow 5 (10) 15 microns.

DISTRIBUTION: Upper Jurassic and Lower Cretaceous. Abundant.

REMARKS: Pityosporites similis Balme, 1957 is probably conspecific with A. thomasii.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 14, fig. 11. Depth 2815 to 2824 feet; Clearwater Formation, Shale Member.

Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 14, fig. 12. Depth 1781 to 1791 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 14, fig. 11. Slide No. Micro. 196; co-ord. 11.9/38.

Pl. 14, fig. 12. Slide No. Micro. 111; co-ord. 12.6/45.8.

Alisporites rotundus Rouse, 1959

Plate 14, figures 13, 14; plate 15, figures 1, 2

1959 Alisporites rotundus Rouse, Micropaleontology 5(3), p. 316, pl. 1, fig. 10.

DESCRIPTION: Bisaccate; central body ill-defined and circular in equatorial section; bladders well developed and as long or longer than the central body giving the whole grain a smooth, oval shape; proximal cap thick; bladders distally attached and slightly distally pendant, covering most of the distal face, leaving only a narrow parallel-sided distal furrow, the sides of which mark the bladder bases; ornamentation coarsely reticulate on lateral regions, grading into finely reticulate to smooth in the region of the distal furrow.

SIZE RANGE: Total breadth of grain 75 (95) 120 microns.

Breadth of central body 45 (53) 65 microns.

Length of central body 55 (65) 75 microns.

Breadth of bladders 32 (43) 53 microns.

Length of bladders 58 (65) 78 microns.

Width of distal furrow 8 (12) 15 microns.

DISTRIBUTION: Upper Jurassic? and Lower Cretaceous. Abundant. First described by Rouse (1959) from the Kootenay Formation of western Canada.

REMARKS: This species is very similar to Alisporites opii (Daugherty) restricted Potonie and Kremp 1956, but can be distinguished from it by its comparatively thinner proximal cap. Abietineaepollenites microalatus Potonie, 1951 and Pityosporites grandis (Cookson) Balme, 1957, also have a close resemblance to A. rotundus.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 14, figs. 13, 14. Depth 2815 to 2824 feet; Clearwater Formation, Shale Member.

Pl. 15, fig. 2. Depth 2860 to 2869 feet; Clearwater Formation, Shale Member.

Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 15, fig. 1. Depth 1816 to 1826 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 14, fig. 13. Slide No. Micro. 167; co-ord. 12/37.5.

Pl. 14, fig. 14. Slide No. Micro. 168; co-ord. 12/38.

Pl. 15, fig. 1. Slide No. Micro. 148; co-ord. 12/38.5.

Pl. 15, fig. 2. Slide No. Micro. 206; co-ord. 11.5/43.

Genus Cedripites Wodehouse, 1933

1933 Cedripites eocenicus Wodehouse, Bull. Torrey Bot. Club 60, pp. 489-490, fig. 13, (type species).

DIAGNOSIS: Bisaccate pollen with thick proximal cap and somewhat curved marginal crest; bladders are fused with proximal cap giving the impression that they are continuous along the proximal pole; bladders are concave on the distal side and partially cover the central body in that region.

Cedripites cretaceus Pocock, 1962

Plate 15, figures 3-5

1962 Cedripites cretaceus Pocock, Palaeontographica B, 111, p. 63, pl. 9, fig. 145.

DESCRIPTION: Bisaccate; central body oval to somewhat circular in equatorial outline; proximal cap thick; bladders distally pendant, concave on distal side partially covering the central body in that region; the exine of the bladders fused with the exine of the proximal cap giving the impression that they continue along the proximal pole; slight flexure present at the point of attachment of bladders with the body; bladders reticulate, proximal cap granulose.

SIZE RANGE: Total breadth of grain 75 (85) 100 microns.

Breadth of central body 58 (62) 66 microns.

Length of central body 52 (53) 55 microns.

Breadth of bladders 36 (42) 50 microns.

Length of bladders 58 (59) 60 microns.

Thickness of proximal cap 5 microns.

DISTRIBUTION: Barremian? to Albian. Common. In western Canada this species is more abundant in the Lower Mannville strata. It occurs throughout the Mannville Group.

AFFINITY: The genus Cedripites has a morphological pattern similar to the pollen of extant Cedrus, family Pinaceae. However, there is no proof that the transition conifers of the Mesozoic had segregated themselves into distinct families in the modern sense by the Lower Cretaceous times.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 15, fig. 3.	Depth 3084 to 3093 feet;	Ellerslie Member.
Pl. 15, fig. 4.	Depth 2514 to 2523 feet;	Grand Rapids Formation.
Pl. 15, fig. 5.	Depth 2782 to 2785 feet;	Clearwater Formation, Shale Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 15, fig. 3.	Slide No. Micro. 235;	co-ord. 11.6/43.8.
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Pl. 15, fig. 4.	Slide No. Micro. 181;	co-ord. 11.8/39.5.
Pl. 15, fig. 5.	Slide No. Micro. 188;	co-ord. 12/38.5.

Cedripites canadensis Pocock, 1962

Plate 15, figure 6

1962 Cedripites canadensis Pocock, Palaeontographica B, 111, 1-3, pp. 63, 64, pl. 10, figs. 149-150.

DESCRIPTION: Bisaccate; equatorial outline of the central body circular; bladders distally pendant, concave, and covering a part of distal surface; bladders and the central body in the same sweeping curve in lateral view; bladders shorter than the central body in distal view; exine of proximal cap granulose, distal furrow straight; bladders reticulate.

SIZE RANGE: Total breadth of the grain 60 to 90 microns.

Breadth of the central body 40 to 70 microns.

Height of the central body 37 to 60 microns.

DISTRIBUTION: Barremian? to Middle Albian. Very rare. This species occurs throughout the Mannville Group.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 15, fig. 6. Depth 3174 to 3179 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 15, fig. 6. Slide No. Micro. 247; co-ord. 10/39.

Genus Parvisaccites Couper, 1958

1958 Parvisaccites radiatus Couper, Palaeontographica B, 103, p. 154, pl. 29, figs. 5, 6, (type species).

DIAGNOSIS: The grain generally broader than long; bladders very small in

comparison with the central body of the grain; radially arranged thickenings on distally pendant bladders; proximal cap and crest well developed.

Parvisaccites radiatus Couper, 1958

Plate 15, figure 7

1958 Parvisaccites radiatus Couper, Palaeontographica B, 103, p. 154, pl. 29, figs. 5, 6.

DESCRIPTION: Bisaccate; grain broader than long; central body more or less circular in equatorial outline; bladders shorter and smaller in comparison with the central body of the grain; bladders distally pendant; radially arranged thickenings run from the base of the bladders to the margin; indistinct reticulation is also present on the bladders; proximal cap and marginal crest well developed; distal furrow smooth.

SIZE RANGE: Total breadth of grain 45 to 75 microns.

Breadth of central body 40 to 50 microns.

Length of central body (average) 38 microns.

Breadth of bladders (average) 22 microns.

Length of bladders (average) 32 microns.

DISTRIBUTION: Berriasian to Aptian. Rare. In western Canada this species makes its first appearance in the Ellerslie Member and continues into the Upper Mannville strata with a progressive reduction in frequency. In England, although it makes its first appearance in the Fairlight Clay (Berriasian) in the Weald Outcrop, it becomes abundant only in the Weald Shale, the Weald Marl and the Lower Greensand (Barremian - Aptian) of the Isle of Wight. An important stratigraphic marker.

AFFINITY: Parvisaccites is very similar to the modern genus Dacrydium of

the family Podocarpaceae which also has small radially thickened bladders.

REMARKS: The genus Parvisaccites can be distinguished from Podocarpidites by its relatively smaller bladders which are shorter in length than the central body, and the radial thickenings on the bladders.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 15, fig. 7. Depth 3010 to 3019 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 15, fig. 7. Slide No. Micro. 211; co-ord. 10/40.

Genus Phyllocladidites Cookson ex Couper, 1953

- 1947 Disaccites (Phyllocladidites) mawsonii Cookson, B.A. N.Z. Antarctic Research Expedition 1929-1931, Rpts.- Ser. A, vol. 2, pt. 8, p. 133, pl. 14, figs. 22-28.
- 1953 Phyllocladidites mawsonii Cookson in Couper, New Zealand Geol. Surv., Paleont. Bull. 22, p. 38, pl. 9, fig. 135, (type species).
- 1953 Dacrydiumites mawsonii (Cookson) Cookson, Aust. J. Bot. 1, p. 66, pl. 1, figs. 9-26.
- 1957 Dacrydium mawsonii (Cookson) Cookson, Proc. Roy. Soc. Victoria, vol. 69, p. 53.
- 1960 Dacrydiumites mawsonii Cookson in Couper, New Zealand Geol. Surv., Paleont. Bull. 32, p. 43, pl. 3, figs. 7-8.

DIAGNOSIS: Bisaccate; equatorial outline of the body circular, oval or polygonal; proximal cap distinct and extends onto the distal surface; bladders very small with indistinct reticulum, strongly distally pendant; bladders small and do not extend far beyond the equator of the central body; a broad, clearly defined distal furrow present between the two bladders; bladders often thick and rigid; exine firm., finely granular, and conspicuously thickened at the proximal root of each bladder close to the equatorial margin.

Phyllocladidites mawsonii forma verrucosus (Cookson) n.comb.

Plate 15, figures 8, 9

1957 Dacrydium mawsonii forma verrucosus Cookson, Proc. Roy. Soc. Victoria, vol. 69, pp. 47, 53, pl. 9, figs. 15-16.

DESCRIPTION: Bisaccate; equatorial outline of the grain oval to ellipsoidal, varying in shape according to the degree of expansion; the exine of the proximal cap ornamented by well defined and closely arranged verrucae; bladders small with indistinct reticulum, strongly distally pendant, not extending far beyond the equator of the central body in polar view; a broad, clearly defined distal furrow present between the bladders; exine firm and slightly thickened at the proximal root of each bladder close to the equatorial margin.

SIZE RANGE: Total breadth of grain 50 to 57 microns.

Breadth of central body 40 to 46 microns.

Height of central body 28 to 32 microns.

DISTRIBUTION: Lower Cretaceous to Lower Eocene? Rare. This species is being reported for the first time from Canada. In central Alberta it was recorded from the Wabiskaw and Ellerslie Members. This species appears to be quite abundant in the southern hemisphere where it has been reported from Australia, New Zealand and Antarctic in sediments ranging from Lower Cretaceous to Eocene in age.

AFFINITY: The probable affinity of Phyllocladidites is with Dacrydium of the family Podocarpaceae.

REMARKS: Disaccites (Phyllocladidites) mawsonii Cookson, 1947 was not created as a new genus but as a new sporomorph. Couper (1953), validated Phyllocladidites as a genus by designating P. mawsonii as the type species, making this genus

valid for the first time. Meanwhile, Cookson (1953) changed the name Phyllocladidites to Dacrydiumites, because it was shown to be related to Dacrydium. However, this change in name was unwarranted because Phyllocladidites which is a form-genus could have been transferred to the status of an organ-genus without a change in name or diagnosis. Instead of changing the name, the probable relationships could have been expressed in the description. Finally, Cookson (1957) appears to have become entirely convinced of its definite taxonomic position and transferred it to the natural genus Dacrydium.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 15, fig. 8. Depth 2896 to 2905 feet; Wabiskaw Member.

Pl. 15, fig. 9. Depth 3075 to 3084 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 15, fig. 8. Slide No. Micro. 207; co-ord. 12.1/42.9.

Pl. 15, fig. 9. Slide No. FA3075-3084-4; co-ord. 0/46.2.

Phyllocladidites sp.

Plate 15, figure 10

DESCRIPTION: Bisaccate; equatorial outline of the body circular; exine finely granular; bladders elongated, narrow, strongly distally pendant, small, not extending beyond the equator of the central body in polar view; bladders thick with no indication of a reticulum and attached by their whole length to the distal surface of the central body; a broad, clearly defined distal furrow present between the bladders.

SIZE RANGE: Total breadth of grain 62 microns.

Breadth of central body 58 microns.

Length of central body 60 microns.

Breadth of bladders 20 microns.

Length of bladders 42 microns.

DISTRIBUTION: Middle Albian. Very rare. A single specimen of this species was recorded from the Wabiskaw Member.

REMARKS: The described specimen is close to Podocarpidites otagoensis Couper, 1953 both in dimensions as well as shape. However, the bladders appear to be too thick, and the proximal cap or the marginal crest etc. cannot be clearly distinguished on the central body.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 15, fig. 10. Depth 2932 to 2938 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 15, fig. 10. Slide No. Micro. 214; co-ord. 11/42.8.

Genus Podocarpidites Cookson ex Couper, 1953

- 1947 Podocarpidites ellipticus Cookson, B.A. N.Z. Antarctic Research Expedition 1929-1931, Reports Ser. A2(8), p. 131, pl. 13, fig. 6, (type species).
- 1953 Podocarpidites cf. ellipticus (Cookson) Couper, New Zealand Geol. Surv., Pal. Bull. No. 22, p. 35.
- 1957 Pityosporites cf. P. ellipticus (Cookson) Balme, C.S.I.R., Australia, Coal Res. Sect., Ref. T.C. 25, pp. 35, 36, pls. 9, 10, figs. 104-107.

DIAGNOSIS: Bisaccate pollen grains; equatorial outline of the central body oval to polygonal; marginal crest visible; bladders large and distally pendant and cover the distal surface except for a parallel-sided area corresponding to the distal leptoma; the length of the central body always less than the length of the bladders. This genus includes bisaccate forms with a very distinct central body, marginal crest, and large, slightly pendant bladders.

Podocarpidites cf. P. ellipticus Cookson, 1947

Plate 15, figure 11

- 1947 Podocarpidites ellipticus Cookson, B.A. N.Z. Antarctic Research Expedition 1929-1931, Reports Ser. A2(8), p. 131, pl. 13, fig. 6.
- 1953 Podocarpidites cf. ellipticus (Cookson) Couper, New Zealand Geol. Surv., Pal. Bull. No. 22, p. 35.
- 1957 Pityosporites cf. P. ellipticus (Cookson) Balme, C.S.I.R., Australia, Coal Res. Sect., Ref. T.C. 25, pp. 35, 36, pls.9, 10, figs. 104-107.

DESCRIPTION: Bisaccate; equatorial outline of the central body oval to almost circular; marginal crest distinct; bladders large, thin-walled, distally pendant with fine reticulation and a faint indication of radial ornamentation; proximal cap and marginal crest granulose.

SIZE RANGE: Total breadth of grain 48 (62) 73 microns.

Breadth of central body 30 (36) 42 microns.

Length of central body 34 (41) 55 microns.

Breadth of bladders 24 (30) 35 microns.

Length of bladders 40 (50) 61 microns.

DISTRIBUTION: Jurassic, Cretaceous and Tertiary. Abundant. In western Canada this species is present throughout the Mannville Group. Balme (1957), reported its occurrence from the Jurassic and Cretaceous of Western Australia. Cookson (1947), described it from the Tertiary sediments of Antarctic.

AFFINITY: The pollen of the form-genus Podocarpidites are similar to those of the modern family Podocarpaceae.

REMARKS: Couper (1953) proposed to emend Cookson's (1947) diagnosis of Podocarpidites in order to include fossil pollen with more than two air bladders, on the basis that the number of bladders vary among the modern Podocarpaceae, and

are not limited to only two. Since Podocarpidites was proposed by Cookson as a sporotype, it was never meant to accommodate all the pollen grains of the family Podocarpaceae. The emendation by Couper is, therefore, not justified and Cookson's original diagnosis restricting the genus Podocarpidites to only bisaccate forms should stand. Cookson (1947), however, proposed another form-genus Microcachrydites which was meant to accommodate pollen grains with a variable number of bladders.

Since Pityosporites has been redescribed and restricted by Manum (1960), it can no longer be used in the broad sense of Balme (1957).

The Canadian species of Podocarpidites cf. P. ellipticus are slightly larger than those from Australia and New Zealand.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 15, fig. 11. Depth 1781 to 1791 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 15, fig. 11. Slide No. Micro. 115; co-ord. 5/38.4.

Podocarpidites multesimus (Bolkhovitina) Pocock, 1962

Plate 15, figures 12, 13

1956 Podocarpus multesima Bolkhovitina, Trans. Geol. Inst., Acad. Sci. U.S.S.R., No. 2, p. 127, pl. 24, fig. 235.

1962 Podocarpidites multesimus (Bolkhovitina) Pocock, Palaeontographica B, 111, p. 67, pls. 10, 11, figs. 161-163.

DESCRIPTION: Bisaccate; equatorial outline of the central body more or less circular; marginal crest present; proximal cap granulose; bladders longer than the central body; distally pendant; in deviant forms one bladder may become greatly enlarged; bladders finely reticulate with faint indications of radial ornamentation.

SIZE RANGE: Total breadth of grain 58 (68) 77 microns.

Breadth of central body 25 (32) 36 microns.

Length of central body 25 (33) 37 microns.

Breadth of bladders 28 (34) 40 microns.

Length of bladders 38 (45) 53 microns.

DISTRIBUTION: Jurassic and Cretaceous. Abundant. In western Canada this species occurs throughout the Mannville Group. It has been described from the Lower Jurassic of Vilyui Basin, U.S.S.R.

REMARKS: Podocarpidites biformis Rouse, 1957 has been placed in synonymy with P. multesimus by Pocock (1962). Since the former has a larger size range (75-90 microns), with coarsely reticulate bladders, and also a dense reticulation on the central body, it is probably not conspecific with P. multesimus.

LOCALITY OF FIGURED SPECIMENS: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 15, fig. 12.	Depth 3582 to 3592 feet;	Calcareous Member.
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Pl. 15, fig. 13.	Depth 3696 to 3706 feet;	Ellerslie Member.
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REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 15, fig. 12.	Slide No. Micro. 7;	co-ord. 4.2/47.8.
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Pl. 15, fig. 13.	Slide No. Micro. 15;	co-ord. 2.2/58.8.
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Podocarpidites ornatus Pocock, 1962

Plate 15, figure 14

1962 Podocarpidites ornatus Pocock, Palaeontographica B, 111, pp. 67, 68, pl. 11, figs. 164-166.

DESCRIPTION: Bisaccate; equatorial outline of the central body sub-circular with crenulate margin; length of central body more than the breadth; marginal crest present; length of the bladders approximately equal to the length of the central body; bladders distally pendant and mainly distally attached, but unlike other forms the

points of attachment also extend well onto the proximal side; distal furrow narrow with parallel sides; proximal cap granulose to verrucose; bladders finely reticulate with a faint indication of radial ornamentation.

SIZE RANGE: Total breadth of grain 70 to 92 microns.

Breadth of central body 40 to 56 microns.

Length of central body 50 to 60 microns.

Breadth of bladders 32 to 42 microns.

Length of bladders 45 to 65 microns.

DISTRIBUTION: Barremian? to Aptian. Rare. In western Canada this species appears to be restricted to the Ellerslie Member.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 15, fig. 14. Depth 3165 to 3174 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 15, fig. 14. Slide No. Micro. 245; co-ord. 11.1/40.2.

Podocarpidites minisculus n. sp.

Plate 15, figures 15, 16

DESCRIPTION: Bisaccate; central body oval; length of central body always more than the breadth; marginal crest present; bladders distally pendant, longer than the central body and very thin-walled; proximal cap scabrate; bladders finely reticulate.

SIZE RANGE: Total breadth of grain 48 to 56 microns. Holotype 51 microns.

Breadth of central body 28 to 39 microns. Holotype 30.6 microns.

Length of central body 30 to 41 microns. Holotype 40.8 microns.

Height of central body 25 to 31 microns.

Breadth of bladders 19 to 22 microns. Holotype 22 microns.

Length of bladders 40 to 48 microns. Holotype 47.5 microns.

DISTRIBUTION: Barremian? to Middle Albian. Rare. In central Alberta this species is found throughout the Mannville Group.

REMARKS: This species is very close to the specimens of Podocarpidites cf. P. decorus (Bolkhovitina, 1953) Pocock, 1962, illustrated by Pocock on pl. 10, figs. 159, 160. However, there are certain discrepancies in measurements. In his description (p. 66) Pocock gives the length of the central body as 29 (31) 39 microns and the length of the bladders as 20 (28) 36 microns, which means that the central body is longer than the bladders. If this is so, these specimens should not have been placed under the form-genus Podocarpidites because its generic diagnosis clearly states "the length of the central body is always less than the length of the bladders". On the other hand, the specimens illustrated by Pocock do have a central body whose length is less than the length of the bladders. If this latter condition is true, his specimens had nothing in common with the holotype of Podocarpus decora Bolkhovitina, 1953, with which he compared his specimens. P. decora has very minute and short bladders and an elongated body and does not agree with the generic diagnosis of the form-genus Podocarpidites.

TYPE LOCALITY: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Holotype: Pl. 15, fig. 15.	Depth 2689 to 2699 feet;	Clearwater Formation, Shale Member.
Pl. 15, fig. 16.	Depth 2598 to 2607 feet;	Grand Rapids Formation.
REPOSITORY: Res. Coun. Alberta Palynological Type Coll.		
Holotype: Pl. 15, fig. 15.	Slide No. Micro. 183;	co-ord. 11/40.5.
Pl. 15, fig. 16.	Slide No. Micro. 180;	co-ord. 12/38.8.

Podocarpidites canadensis Pocock, 1962

Plate 16, figures 1-3

1962 Podocarpidites canadensis Pocock, Palaeontographica B, 111, p. 66, pl. 10, figures 157, 158.

DESCRIPTION: Bisaccate; equatorial outline of the central body four sided to sub-circular; marginal crest present; bladders distally pendant and longer than the central body; distal furrow with concave lips; proximal crest and cap granulose; bladders reticulate with faint indications of radial ornamentation.

SIZE RANGE: Total breadth of grain 90 (115) 130 microns.

Breadth of central body 50 (65) 80 microns.

Length of central body 45 (60) 75 microns.

Breadth of bladders 43 (48) 58 microns.

Length of bladders 54 (70) 90 microns.

DISTRIBUTION: Barremian? to Aptian. Common. In western Canada this species is more common in the Lower Mannville strata, and rare in the Upper Mannville.

REMARKS: P. canadensis can be distinguished from Podocarpus major (Naumova) Bolkhovitina by its shorter bladders.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 16, fig. 1. Depth 3174 to 3179 feet; Ellerslie Member.

Pl. 16, fig. 3. Depth 3093 to 3102 feet; Ellerslie Member.

Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 16, fig. 2. Depth 3582 to 3592 feet; Calcareous Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 16, fig. 1. Slide No. Micro. 250; co-ord. 10.8/43.2.

Pl. 16, fig. 2. Slide No. Micro. 6; co-ord. 6.5/44.

Pl. 16, fig. 3. Slide No. Micro. 240; co-ord. 11/44.8.

Aberrant Podocarpidites pollen

Plate 16, figure 4

DESCRIPTION: Bisaccate; bladders rigid with a thickened strip running across

at their bases. Total breadth of the grain 63 microns. A single specimen was recorded.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 16, fig. 4. Depth 2932 to 2938 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 16, fig. 4. Slide No. Micro. 219; co-ord. 9.9/40.1.

Podocarpidites sp.

Plate 16, figure 5

DESCRIPTION: Bisaccate; central body oval and broader than long, marginal crest present; bladders distally pendant and very close to one another; distal furrow with concave lips; cap granulose; bladders coarsely reticulate with faint indications of radial ornamentation.

SIZE RANGE: Total breadth of grain 142 microns.

Breadth of central body 88 microns.

Length of central body 82 microns.

Breadth of bladders 68 microns.

Length of bladders 104 microns.

DISTRIBUTION: Barremian? Very rare. In central Alberta a single specimen of this species was recorded near the base of the Ellerslie Member.

REMARKS: This species is similar to Podocarpus andiniformis Bolkhovitina, 1956 but in the latter the central body is longer than broad. It has not been formally described because only one specimen was found.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 16, fig. 5. Depth 3174 to 3179 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 16, fig. 5. Slide No. Micro. 248; co-ord. 9.6/40.5.

Podocarpidites naumovai n. name for Podocarpidites major (Naumova) n. comb.
which is homonymous with Podocarpidites major Couper, 1953

Plate 16, figure 6

- 1937 Platysaccus major Naumova, Spores and pollen of the coals of the U.S.S.R.,
17th Int. Geol. Congr. Absts. Papers, U.S.S.R.
- 1953 Podocarpus major (Naumova) Bolkhovitina, Acad. Sci. U.S.S.R., Trans. Inst.
Geol. Sci., vol. 145, Geol. Ser. 61, pl. 11, figs. 8, 9.
- non 1953 Podocarpidites major Couper, N.Z. Geol. Surv. Pal. Bull. 22, p. 36, pl. 4,
fig. 40.

DESCRIPTION: Bisaccate; equatorial outline of the central body oval with a
breadth approximately twice the length; body of the pollen as a whole very much
elongated in width; bladders longer than the body, distally pendant, attached with a
concave base; distal furrow very wide with convex sides; bladders distinctly reticulate
with a marked radial pattern closer to the margin.

SIZE RANGE: Total breadth of grain 116 microns.

Breadth of central body 66 microns.

Length of central body 38 microns.

Breadth of bladders 50 microns.

Length of bladders 58 microns.

Width of distal furrow 15 microns.

DISTRIBUTION: Albian to Cenomanian. Very rare. In central Alberta a few
specimens of this species were recorded from the Clearwater Formation. It has been
reported from the Lower and Middle Albian horizons near the Aral Sea and from the
Cenomanian Stage on the western slope of northern Urals.

REMARKS: Podocarpus major (Naumova) Bolkhovitina, 1953 is transferred
to the form-genus Podocarpidites. However, the name Podocarpidites major (Naumova)

n. comb. would be a later homonym of Podocarpidites major Couper, 1953 and would, therefore, be invalid under Article 64 of the International Code of Botanical Nomenclature (1959). Therefore, a new name Podocarpidites naumovai has been given to this species according to the Article 55 (1) of the Code (1959).

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 16, fig. 6.	Depth 2782 to 2785 feet;	Clearwater Formation, Shale Member.
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REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 16, fig. 6.	Slide No. Micro. 190;	co-ord. 12.5/39.
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Genus Piceapollenites Potonie, 1931

1931 Piceapollenites alatus Potonie, Jb. Preuss. Geol. L.A., vol. 52, p. 5, fig. 31, (type species).

1938 Piceapollenites Thiergart, p. 306.

DIAGNOSIS: Bisaccate pollen grains; equatorial outline more or less oval; bladders small in comparison with the body; bladders nearly as long as the body resulting in a more or less uninterrupted oval outline in polar view; in lateral view they show a small re-entrant angle between the bladder and body; base of the bladders reaches beyond the equator on proximal side; body texture finely granular, bladders coarsely reticulate.

Piceapollenites sp.

Plate 16, figure 7

DESCRIPTION: Bisaccate; bladders smaller in comparison with the body; in lateral view the bladders show small re-entrant angle between the bladder and body, and are nearly as long as the body; bladders longer than broad; base of the bladders

reaches beyond the equator on proximal side; body texture granular, bladders coarsely reticulate.

SIZE RANGE: Length of the body 112 microns.

Length of the bladders 100 microns.

Breadth of the bladders 60 microns.

Total breadth of grain about 180 microns (inferred).

DISTRIBUTION: Middle Albian. Very rare. In central Alberta a single specimen of this species was found in the Wabiskaw Member.

AFFINITY: Similar in morphology to the modern grains of the genus Picea of the family Pinaceae.

REMARKS: This specimen is very similar to Picea grandivescipites Wodehouse, 1933, illustrated by Rouse (1957, pl. 2, fig. 11), but appears to be larger in size.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 16, fig. 7. Depth 2905 to 2914 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 16, fig. 7. Slide No. Micro. 209; co-ord. 11.4/41.2.

Genus Pityosporites (Seward, 1914) Manum, 1960

- 1914 Pityosporites antarcticus Seward, Brit. Antarctic (Terra Nova) Exped. 1910, Nat. Hist. Report, Geol. 1: p. 23, pl. 8, fig. 45, pl. 7, fig. 67, (type species).
- 1954 Pityosporites (Seward) emend. Potonie and Klaus, Geol. Jb. 68, p. 534.
- 1958 Pinuspollenites Raatz ex Potonie, Beih. Geol. Jb., p. 62, pl. 8, figs. 75, 76.
- 1960 Pityosporites antarcticus (Seward) Manum, Nytt Mag. Bot., vol. 8, pp. 14, 15, pl. 1, figs. 1-4.

DIAGNOSIS: Bisaccate pollen grains; bladders distally pendant, narrowing towards their roots and diverging; proximally the roots reach the equator of the body

or slightly beyond it; distally they are separated by a more or less narrow furrow; bladders reticulate; body wall smooth or very finely sculptured; exine thickness moderate and not conspicuously increasing towards the roots of the bladders.

Pityosporites constrictus n. sp.

Plate 16, figures 8, 9

DESCRIPTION: Bisaccate; bladders distally pendant narrowing towards their roots and diverging; the roots reach slightly beyond the equator; the space separating the two bladders on the distal side about 15 microns wide; central body oval, broader than long; bladders reticulate; body finely granulate; exine uniformly thick.

SIZE RANGE: Total breadth of grain 70 to 80 microns. Holotype 74 microns.

Breadth of central body 45 to 55 microns. Holotype 50 microns.

Length of central body 37 to 48 microns. Holotype 42 microns.

Breadth of bladders 27 to 34 microns. Holotype 29 microns.

Length of bladders 35 to 42 microns. Holotype 40 microns.

Width of distal furrow about 15 microns.

DISTRIBUTION: Barremian? to Middle Albian. Common. In central Alberta this species is common in the Lower Mannville strata, and rare in the Upper Mannville.

AFFINITY: Seward (1914) suggested that Pityosporites had an affinity with the Pinaceae, though he admitted that "on geographical grounds it would seem more probable that the spores belonged to some plant allied to Podocarpus, Dacrydium or Microcachrys". The narrowing of the bladders towards their base is typical of pinaceous pollen.

REMARKS: Potonie and Klaus (1954) emended Seward's diagnosis of the form-genus Pityosporites without examining the holotype. Manum (1960) re-examined the holotype and found that some of the characters attributed to the genus by Potonie and Klaus were erroneous to such an extent that the emended genus excluded the type species itself, and therefore, were untenable. Manum's new diagnosis, based on a detailed examination of the holotype, restricts the use of the genus Pityosporites. Balme's (1957) suggestion that the genus Pityosporites should serve as a morphographic category for all isolated fossil bisaccate pollen lacking characters which would distinguish them from abietineous pollen is unacceptable. His placing of genera belonging to Vitreisporites and Podocarpidites under Pityosporites is not justified.

TYPE LOCALITY: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Holotype: Pl. 16, fig. 8. Depth 3010 to 3019 feet; Ellerslie Member.

Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 16, fig. 9. Depth 3778 to 3784 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 16, fig. 8. Slide No. Micro. 228; co-ord. 9.2/43.5.

Pl. 16, fig. 9. Slide No. Micro. 63; co-ord. 11/36.3.

Pityosporites alatipollenites (Rouse) n. comb.

Plate 16, figure 10

1959 Pinus alatipollenites Rouse, Micropaleo., vol. 5, no. 3, p. 314, pl. 1, fig. 7.

DESCRIPTION: Bisaccate pollen grains; bladders distally pendant, slightly constricted towards the base, diverging; bladders small as compared to the body and their base barely reaches the equator of the body; the space separating the two bladders on the distal side about 16 microns wide; central body elliptical, broader than long, ornamentation finely to coarsely reticulate; bladders coarsely reticulate; exine

uniformly thick.

SIZE RANGE: Total breadth of grain about 65 microns.

Breadth of central body about 51 microns.

Height of central body about 41 microns.

Width of bladders about 24 microns.

Width of distal furrow about 16 microns.

DISTRIBUTION: Upper Jurassic? to Upper Cretaceous. Rare. In central Alberta this species occurs throughout the Mannville Group. Rouse (1959), first described it from the Kootenay Formation (Upper Jurassic?) and also recorded it from the Brazeau Formation (Upper Cretaceous).

REMARKS: Under a taxonomic approach which favours the use of natural genera these specimens would be placed under Pinus alatipollenites.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 16, fig. 10. Depth 1826 to 1836; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 16, fig. 10. Slide No. Micro. 151; co-ord. 9.5/39.8.

Aberrant Pityosporites pollen

Plate 16, figure 11

DESCRIPTION: Bisaccate; bladders strongly distally pendant and constricted at the base, body consists of two pollen grains grown together which have failed to separate on the proximal side. Total breadth of grains 56 microns; breadth of the central body 40 microns. A single specimen was recorded.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 16, fig. 11. Depth 3174 to 3179 feet; Ellerslie Member.
 REPOSITORY: Res. Coun. Alberta Palynological Type Coll.
 Pl. 16, fig. 11. Slide No. Micro. 246; co-ord. 9.8/42.

Genus Tsugaepollenites Potonie and Venitz, 1934

- 1931 Sporonites igniculus Potonie, Z. Braunkohle, H. 27, p. 556, fig. 2.
 1934 Tsugaepollenites igniculus Potonie and Venitz, Arb. Inst. Palaeob. Petr.
 Brennsteine, 5, p. 17, pl. 1, fig. 8, (type species).
 1937 Tsugaepollenites Raatz, Abh. Preuss. Geol. L-A. Berlin, H. 183, p. 15.

DIAGNOSIS: Pollen grains; equatorial outline more or less circular, with equatorial velum which may be very narrow, frill-like, radially folded; outer margin irregularly undulating to indented; exine of central body rugulate.

Tsugaepollenites mesozoicus Couper, 1958

Plate 17, figure 1

- 1958 Tsugaepollenites mesozoicus Palaeontographica B, 103, p. 155, pl. 30, figs. 8-10.

DESCRIPTION: Grains saccate; equatorial outline circular to broadly elliptical; equatorial velum quite narrow; exine of distal surface very thin and almost smooth over a circular area which is surrounded by a fringe of saccate projections; exine at the proximal pole is also saccate, but the sacchi are not so well developed as around the equator; the ornamentation of the polar area gradually merges into the pattern of the equatorial fringe.

SIZE RANGE: Equatorial diameter (including fringe) 40 to 85 microns.

DISTRIBUTION: Jurassic and Cretaceous. Rare. In western Canada this species has been reported from the Gravelbourg Formation to the Colorado Formation

by Pocock (1962).

AFFINITY: T. mesozoicus resembles the recent species of Tsuga, such as Tsuga canadensis, of the family Pinaceae.

LOCALITY OF FIGURED SPECIMEN: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 17, fig. 1. Depth 3748 to 3758 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 17, fig. 1. Slide No. Micro. 57; co-ord. 5.2/49.9.

Genus Classopollis (Pflug, 1953) Pocock and Jansonius, 1961

- 1950 Conifer pollen. Reissinger, Palaeontographica B, 90, p. 114, pl. 14, figs. 15-16.
- 1953 Classopollis classoides Pflug, Palaeontographica B, 95, p. 91, pl. 16, figs. 29-31, (type species).
- 1961 Classopollis classoides (Pflug) Pocock and Jansonius, Micropaleontology, 7(4), pp. 439-449, pl. 1.

DIAGNOSIS: Distally monoporate pollen, pore not always clearly shown; equatorial outline spherical or oval and lateral view flattened acorn-shaped; exine two-layered; ectexine absent over a circular area around the distal pole and over a triangular area around the proximal pole; endexine at the proximal pole shows a faint trilete scar which has no germinal function; striations always present in a band surrounding the equator, this usually marks a zone of exinal thickening.

Classopollis classoides (Pflug) Pocock and Jansonius, 1961

Plate 17, figure 2

- 1950 Conifer pollen. Reissinger, Palaeontographica B, 90, p. 114, pl. 14, figs. 15-16.
- 1953 Classopollis classoides Pflug, Palaeontographica B, 95, p. 91, pl. 16, figs. 29-31.
- 1961 Classopollis classoides (Pflug) Pocock and Jansonius, Micropaleontology, 7(4), pp. 439-449.

DESCRIPTION: Distally monoporate pollen with only a faint indication of a pore; spherical in shape; exine two-layered, ectexine absent from the poles, a very faint small (rays less than 3 microns) and non-functional trilete mark present at the proximal pole in some cases; striations on a zone of exinal thickening present in a band surrounding the equator; commonly occurring in tetrads. In the Mannville Group the genus Classopollis is rare and also probably reworked. The features exhibited on the few ill-preserved specimens are insufficient for any detailed description.

SIZE RANGE: Polar diameter (average) 23 microns.

Equatorial diameter (average) 28 microns.

DISTRIBUTION: Jurassic and Cretaceous. Pocock (1962) reported this species to be abundant in the Vanguard Formation (Upper Jurassic) and rare in Cretaceous. First described from the Lias Stage of Europe by Pflug (1953).

AFFINITY: Classopollis type pollen were produced by plants of gymnospermous affinity probably belonging to the genera Cheirolepis, Pagiophyllum or Brachyphyllum.

DISCUSSION: Pflug's (1953) original generic diagnosis "tricolporate, rarely tetracolporate" for Classopollis was obviously inaccurate. Couper (1958) emended Pflug's diagnosis, but while most of his morphological interpretations were correct, he designated Classopollis torosus (Reissinger, 1950) Couper, 1958 as the type species, and put C. classoides Pflug, 1953 in synonymy. However, they do not appear to be conspecific (Potonie, 1960). Couper (1958), also failed to mention the monoporate nature of the grains. Therefore, the emended diagnosis by Pocock and Jansonius (1961) appears to be justified.

LOCALITY OF FIGURED SPECIMEN: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 17, fig. 2. Depth 3726 to 3736 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 17, fig. 2. Slide No. Micro. 60; co-ord. 16.1/41.2.

Genus Leioaletes Staplin, 1960

1960 Leioaletes aliquandostriatus Staplin, Palaeontographica B, 107, p. 5, pl. 1, fig. 1, (type species).

DIAGNOSIS: Spores without germinal sutures but occasionally with a few very fine indistinct grooves parallel to the long axis of the spore; shape ellipsoidal; sculpture minor.

Leioaletes calvatus n. sp.

Plate 17, figure 3

DESCRIPTION: Alete; outline ellipsoidal with well-rounded ends, exine smooth, but may be corroded, colour light-yellow.

SIZE RANGE: Length about 67 microns. Holotype 67 microns.

Breadth about 28 microns. Holotype 28 microns.

DISTRIBUTION: Middle Albian. Rare. In central Alberta only a few specimens were found in the upper portion of the Grand Rapids Formation.

AFFINITY: Similar in morphology to the pollen of Podozamites.

TYPE LOCALITY: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Holotype: Pl. 17, fig. 3. Depth 2478 to 2487 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 17, fig. 3. Slide No. Micro. 172; co-ord. 10.5/39.

- 1957 Exesipollenites tumulus Balme, C.S.I.R., Australia, Ref. T.C. 25, p. 39, pl. 11, figs. 123-125, (type species).

DIAGNOSIS: Pollen grains with circular or oval outline; smooth to faintly granulose. Exine is darker in a circular or triangular area at one of the poles. In the centre of this thickening there is a circular area of exinal thinning. The thickened exine gradually becomes lighter and thinner towards the equator.

Exesipollenites tumulus Balme, 1957

Plate 17, figures 4, 5

- 1957 Exesipollenites tumulus Balme, C.S.I.R., Australia, Ref. T.C. 25, p. 39, pl. 11, figs. 123-125.

DESCRIPTION: Pollen grains with circular outline; exine about 2 microns thick, with a few scattered granules; one of the poles is marked by a darker exine in a circular area, about 15 microns in diameter, in the centre of which there is a circular area of exinal thinning about 4 microns in diameter; the darker area of the exine gradually becomes lighter towards the equator.

SIZE RANGE: Equatorial diameter 25 to 35 microns.

DISTRIBUTION: Triassic to Upper Cretaceous. Common. In western Canada this species occurs throughout the Mannville Group. However, Balme (1957) believes that it is of undoubted stratigraphic importance in Western Australia where it is restricted to the Lower Jurassic.

AFFINITY: These are probably related to the family Taxodiaceae or Cupressaceae.

REMARKS: Exesipollenites tumulus Balme, 1957 has a close resemblance

to Spheripollenites scabratus Couper, 1958 with which it may be synonymous in part. However, the two can be distinguished, as S. scabratus has no thickened circular area around one pole or a distinct circular depression in it. Also, its exine is thin and has distinct scabrate ornamentation. Inaperturopollenites Thomson and Pflug, 1953 can be distinguished from Exesipollenites by the lack of darkened circular area around one pole and a circular thinning in the middle of this area.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 17, fig. 4.	Depth 2782 to 2785 feet;	Clearwater Formation, Shale Member.
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Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 17, fig. 5.	Depth 2095 to 2098 feet;	Wabiskaw Member.
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REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 17, fig. 4.	Slide No. Micro. 191;	co-ord. 10.2/37.8.
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Pl. 17, fig. 5.	Slide No. Micro. 159;	co-ord. 10.2/39.2.
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Genus Eucommiidites (Erdtman, 1948) Hughes, 1961

1948 Tricolpites (Eucommiidites) troedssonii Erdtman, Geol. Foren. Forhandl. 70(2), p. 267, figs. 5-10, 13-15.

1957 Trifossapollenites Rouse (pars), Can. J. Bot. 35, p. 372, pl. 3, figs. 65, 66.

1958 Eucommiidites troedssonii (Erdtman) Couper, Palaeontographica B, 103, p. 160, pl. 31, figs. 23-27, (type species).

1961 Eucommiidites (Erdtman) Hughes, Palaeontology 4(2), pp. 292, 293, pl. 37, figs. 1-16.

DIAGNOSIS: Pollen grains with oval equatorial outline; one face is flat and has a long, median furrow with rounded ends which is parallel with the long axis; in the unexpanded condition, the margins of this furrow may close over it in the middle; the opposite face is more convex, bears a ring-furrow near the margin separating the larger part of the face (zonisulcate condition); exine in the ring-furrow is thin and the ring may be incomplete at the ends in the long axis.

Eucommiidites troedssonii Erdtman, 1948

Plate 17, figures 6-9

- 1948 Tricolpites (Eucommiidites) troedssonii Erdtman, Geol. Foren. Forhandl. 70(2), p. 267, figs. 5-10, 13-15.
- 1957 Trifossapollenites Rouse (pars), Can. J. Bot. 35, p. 372, pl. 3, figs. 65, 66.
- 1958 Eucommiidites troedssonii (Erdtman) Couper, Palaeontographica B, 103, p. 160, pl. 31, figs. 23-27.
- 1961 Eucommiidites troedssonii (Erdtman) Hughes, Palaeontology 4(2), pp. 292, 293, pl. 37, figs. 1-16.

DESCRIPTION: Pollen grains with oval equatorial outline; a median furrow, extending almost the whole length of the grain, parallel with the long axis, is present on the flat face, ends of the furrow are rounded; the opposite face is more convex, bears a ring-furrow near the margin, which may be incomplete at the ends in the long axis, exine in the ring-furrow thin.

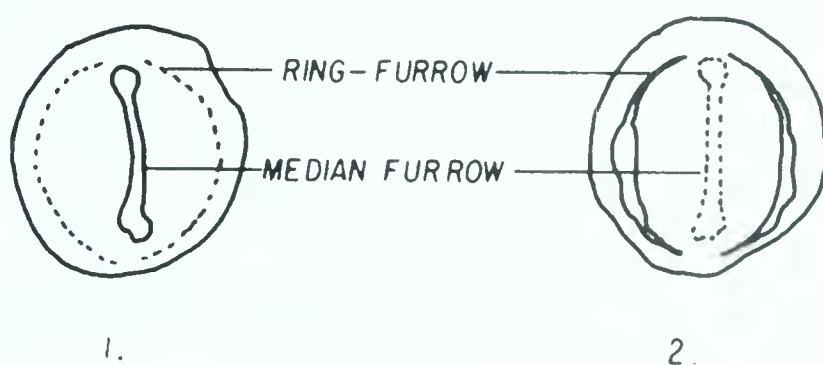


Figure 10. Eucommiidites troedssonii Erdtman.

1. Front view showing the median furrow.
2. Back view showing the ring-furrow incomplete at the ends.

SIZE RANGE: Length (average) 28 microns.

Breadth (average) 24 microns.

DISTRIBUTION: Jurassic and Lower Cretaceous. Common. In western

Canada this species occurs from the Upper Jurassic Fernie shale (Pocock, 1962), to the Grand Rapids Formation. It was first described by Erdtman (1948) from the Lower Lias of N.W. Scania, Sweden. Couper (1958), reported it from the Middle and Upper Jurassic and the Wealden of England.

AFFINITY: Recently, Hughes (1961) found the pollen of the Eucommiidites type in the micropyle and pollen chamber of a dispersed Lower Cretaceous seed, Spermatitis pettensis Hughes, 1961, which is clearly a gymnospermous ovule. The present interpretation of the morphology of the genus Eucommiidites tends to show its affinity with cycadophytes, Ginkgoales and perhaps Chlamydospermales. The original suggestion by Erdtman (1948) about a possible angiospermous origin and tricolpate nature of the pollen of Eucommiidites is contradicted by the recent findings.

REMARKS: The probable orientation of the pollen of Eucommiidites is as yet uncertain. If we compare its morphology with Classopollis which is very similar to it, the ring-furrow must be distal, and the median furrow proximal. On the other hand, the median furrow is very similar to the distal furrow of a cycad pollen. This problem shall remain unsolved until the grain has been seen in its tetrad.

Erdtman (1948), misinterpreted the morphology of Eucommiidites as tricolpate, therefore, Couper (1958) had to emend it. However, even Couper's emended diagnosis was not very accurate and Hughes (1961) brought out a new interpretation of this genus. He interpreted Couper's "two minor "colpi" " as "a ring-furrow which may be complete or broken". Mention of the term "colpi" in the case of a pollen of gymnospermous origin by Couper was entirely out of place. Also, the interpretation of the orientation and position of the poles has been omitted by Hughes in the absence of a conclusive

evidence. The mention of such terms as "monosulcate" "distal sulcus", "proximal or distal face" etc. has been omitted.

Rouse (pers. comm.), now considers Trifossapollenites Rouse, 1957 to be distinct from the genus Eucommiidites. It differs from Eucommiidites in having a long central furrow and two short lateral furrows, all on the same surface. His original specimens from the Oldman Formation (Upper Cretaceous) belong to the genus Trifossapollenites. However, he agrees that at least some of the specimens from the Kootenay Formation (Upper Jurassic to Lower Cretaceous) assigned to the genus Trifossapollenites by him (Rouse, 1959) should be synonymized with the genus Eucommiidites, although the original Trifossapollenites constitutes a distinct genus.

LOCALITY OF FIGURED SPECIMENS: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 17, fig. 6. Depth 2095 to 2098 feet; Wabiskaw Member.

Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 17, figs. 7-9. Depth 2607 to 2616 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 17, fig. 6. Slide No. Micro. 162; co-ord. 10.2/39.2.

Pl. 17, figs. 7-9. Slide No. FA2607-2616-1; co-ord. 0/74.

FAMILY EPHEDRACEAE

Genus Equisetosporites (Daugherty, 1941) emend.

- 1941 Equisetosporites chinleana Daugherty, Carnegie Inst. Washington, Pub. 526, p. 63, pl. 24, fig. 4, (type species).
- 1953 ? Ephedripites Bolkhovitina, Trans. Inst. Geol. Sci., Acad. Sci. U.S.S.R., Rel. 145, Geol. Ser. no. 61, p. 60, pl. 9, fig. 15.
- 1958 Ephedracites Maljavkina, Spores and Pollen Grains from the Lower Cretaceous of the eastern Gobi-depression, VNIGRI, Trudy, Leningrad, No. 119, p. 115, pl. 4, 7.
- 1960 Ephedra chinleana (Daugherty) Scott, Micropaleo., vol. 6, no. 3, p. 271, pl. 1, figs. 1, 8, 10-12, 14-18; text - figs. 1-2.

1961 Striainaperturites Pierce, Minnesota Geol. Surv. Bull. 42, p. 45, pl. 3, fig. 80.

EMENDED DIAGNOSIS: Acolpate pollen grains; ellipsoid; sometimes narrower at one end; exine two-layered; smooth endexine overlain by ectexine; ectexinous ridges unbranched, straight, 2 to 12 microns wide in the middle, narrowing at the longitudinal ends, low, gently rounded, running longitudinally, 8 to 25 in number; in a vertical section along the width the ridges are semi-circular in outline rather than angular, narrow furrows flank the ridges abruptly, 1 to 3.5 microns wide, unbranched, straight; criss cross appearance of the ridges is often produced by the twisting of the grains during fossilization and is not a reliable specific character; ridges mostly coalesce just before reaching the longitudinal ends so that the furrows do not reach the margin, unlike some spores of the family Schizaeaceae (e.g. Anemia) where ridges and furrows extend to the margin; in certain species of Equisetosporites four distinct areas of convergence of ridges are present on the grain, two such areas of convergence near each longitudinal end being opposite to subopposite, in some cases 1 to 3 marginal ridges may join at the longitudinal ends and are continuous? (Scott, 1960); but a simple unsculptured area where all the ridges fuse at the longitudinal ends as in the pollen of modern Ephedra is characteristic for this group (pl. 17, fig. 15); the ectexine usually markedly thickened at the longitudinal ends.

The genus Equisetosporites is emended to include all ephedralean pollen similar in appearance to Equisetosporites chinleana Daugherty, 1941, and Ephedra pollen Type D (Steeves and Barghoorn, 1959). This genus excludes forms similar to Gnetaceaepollenites Thiergart, 1938 and Ephedra pollen Types A, B and C (Steeves and Barghoorn, 1959).

Equisetosporites concinnus n. sp.

Plate 17, figures 10-15

DESCRIPTION: Acolpate pollen grains; ellipsoid, always narrower at one end; exine two-layered; smooth endexine overlain by a thicker ectexine; ectexinous ridges unbranched, straight, 7 to 10 microns wide in the middle, narrowing at the longitudinal ends, low, gently rounded, running longitudinally, 10 to 12 in number; furrows narrow, about 1 micron wide, unbranched, straight; some grains present a criss cross pattern of ridges produced by the twisting of the grains during fossilization; ridges coalesce just before reaching the longitudinal ends, so that the furrows do not reach the margin, a simple unsculptured area where all the ridges fuse is present at the longitudinal ends; ectexine normally 1 micron thick is thickened to about 3 microns at the longitudinal ends.

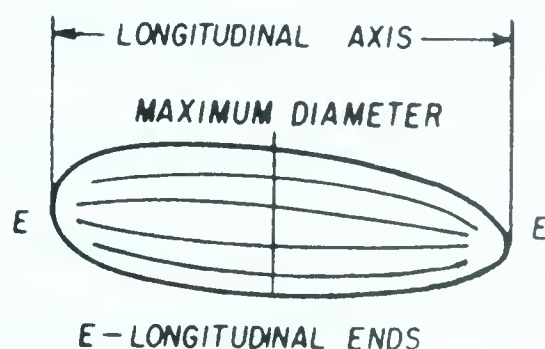


Figure 11. Orientation of an Equisetosporites pollen grain.

SIZE RANGE: Longitudinal axis 75 (82.6) 92 microns.

Holotype 92 microns.

Maximum diameter 32 (34.8) 40 microns.

Holotype 32 microns.

Ratio of longitudinal axis to maximum diameter 1.9 (2.4) 2.9.

DISTRIBUTION: Barremian? Abundant at only one horizon near the base of the Ellerslie Member in Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54,

R. 24, W. 4th Mer.), in central Alberta.

AFFINITY: The pollen of Equisetosporites are very similar to the Ephedra pollen Type D (Steeves and Barghoorn, 1959). The pollen grains of the extant species Ephedra breana are morphologically very close to Equisetosporites. The asymmetrical ridge pattern, where 1 to 3 marginal ridges join at the longitudinal ends and are continuous on the other side, as described in the case of Equisetosporites chinleana, is not typical of most modern Ephedra pollen. However, keeping in mind the antiquity of this species, the extreme variability of morphology within modern Ephedra, and the fact that even some of the modern pollen e.g. Ephedra strobilacea, E. wraithiana and E. foliata show comparable ridge pattern at the longitudinal ends, Triassic species like E. chinleana seem to show affinity with the extant genus Ephedra. However, it cannot be definitely asserted that the modern genus Ephedra, in its present sense, existed in Mesozoic Era. The writer is in complete agreement with Hughes (1961, p. 295) who states: "Palynological evidence of the widespread existence of plants similar to the Chlamydospermales in Mesozoic times is accumulating; no progress has yet been made, however, with macrofossil identification of the group. In this connexion I regret the placing of fossil pollen species in extant genera such as Ephedra (Scott 1960), which is likely to be a hinderance to understanding, if not actually contrary to the Rules of Nomenclature (Potonie 1960, p. 21). If there was a Mesozoic group at all, it is unlikely that its members will prove to be close in affinity to the three surviving relict genera; as has been shown many times with other groups, the evidence of a single organ is quite insufficient."

Wilson (1959), who has described fossil pollen similar in morphology to Ephedra

and Welwitschia from the Flowerpot Formation (Middle Permian) of Oklahoma, did not place them in their natural genera. He placed them in Ephedripites Bolkhovitina or referred to them merely as cf. Welwitschia sp. (see p. 36, pl. 1). However, in the text he refers to the same as Ephedra and Welwitschia. The significance of this treatment is not clear to the writer, but in so far as he has directly referred to his illustrated specimens as Ephedripites he probably intends to formally designate them as such and not as Ephedra. Wilson also agrees that the fossil record of Gnetales aside from pollen, is meager. There are no reliable microfossil identifications of this group in beds older than the Tertiary. He also believes, that perhaps Ephedra and Welwitschia were represented by larger number of species in the past which are extinct now. In the opinion of the writer, it is equally possible that in the past there were more related genera producing pollen morphologically similar to the only surviving genus Ephedra within the family Ephedraceae, which have become extinct since then. In fact, there are no living species of Ephedra which produce ellipsoid pollen narrower at the one longitudinal end, as described in the present work. The possibility that they belonged to a closely related extinct genus and not to the extant genus Ephedra cannot be over-ruled. Only the future macrofloral fossil evidences shall be able to throw some conclusive light on the past relationships within the family Ephedraceae. Meanwhile, in the opinion of the writer, it would be more suitable to place the ephedralean pollen in the organ-genus Equisetosporites which belongs to the family Ephedraceae, but not necessarily to the genus Ephedra.

Although the pollen of Equisetosporites were acolpate, they probably germinated by splitting along one of the furrows.

REMARKS: The position of the two morphological poles in the acolpate pollen grains of Equisetosporites is uncertain. The use of the terms "poles", for referring to the longitudinal ends of the pollen (Scott, 1960) and "polar axis", for the line joining the two longitudinal ends (Steeves and Barghoorn, 1959) in the case of the ephedralean pollen, does not seem to be appropriate. The term pole should be used in relation to the orientation of a pollen or spore in a tetrad. The side facing the points of contact in a tetrad should be called the proximal pole and the opposite surface facing outward, the distal pole. The exact position of these two morphological poles being uncertain in Equisetosporites, the line drawn across the maximum width of the pollen has been referred to as the maximum diameter and the line joining the two longitudinal ends as the longitudinal axis, in the present study.

Equisetosporites belongs to the family Ephedraceae rather than the Schizaeaceae because they have wide, low, gently rounded unbranched ridges, whereas, in the Schizaeaceae the ridges are narrower, high, and are usually branched. The genus Equisetosporites, like modern pollen of the family Ephedraceae, has ridges that coalesce just before reaching the longitudinal ends and are discontinuous, producing a simple unsculptured area at each longitudinal end. In the Schizaeaceae, the ridges from the opposite surfaces join in sequence and are continuous. Equisetosporites is apparently acolpate, whereas the recent as well as fossil species of the genus Schizaea are monolete. Equisetosporites in most cases has an ectexinous thickening at the longitudinal ends which is typical of Ephedra pollen Type D (Steeves and Barghoorn, 1959); no such thickening is found in the family Schizaeaceae.

The genus Gnetaceaepollenites Thiergart, 1938 and Ephedra pollen Types A,

B and C (Steeves and Barghoorn, 1959), are characterized by the presence of fewer angular ridges alternating with branching or sinuous colpi, and are distinct from Equisetosporites (Daugherty, 1941) emend.

The genus Equisetosporites was originally erected by Daugherty (1941) to include "spherical spores with two tightly wrapped elators" which he compared with the spores of recent Equisetales. They were described from the Upper Triassic Chinle Formation. Scott (1960) re-examined the holotype of Equisetosporites chinleana and compared it with better preserved ephedroid pollen from the same formation. From the illustrations, Scott's interpretation, that the so-called "elators" are actually ektexinous ridges, and that the spherical spore is the inner smooth endexine which has become detached from the ektexine, is quite convincing. The writer is in agreement with Scott, that the pollen originally placed in the genus Equisetosporites are morphologically similar to those of the extant genus Ephedra, and not Equisetales. However, for the reasons given earlier, the transfer of Equisetosporites to the extant genus Ephedra does not seem to be appropriate under the circumstances. The natural genus Ephedra can be validly used in this case and have priority only if the synonymizing of the two genera Equisetosporites and Ephedra by Scott (1960) is accepted. If, however, it is not accepted, not only would the use of the name Ephedra for the pollen described under the name Equisetosporites be invalid, but also the transfer of the type species Equisetosporites chinleana to the natural genus Ephedra should not be construed as valid. Under these circumstances the genus Equisetosporites cannot be interpreted as having lost its type species, and would continue to remain valid. In so far as the genus Equisetosporites has priority, no new names or later synonyms e.g. Striainaperturites

etc. can be validly used in its place. The name Equisetosporites cannot be rejected on the grounds of being inappropriate or unsuitable (see Art. 62 of Inter. Code of Bot. Nomen. 1959). There is no other provision in the Code under which the name Equisetosporites can be rejected. Therefore, once it has been decided not to use the extant genus Ephedra, there is no alternative but to use the organ-genus Equisetosporites.

Ephedripites Bolkhovitina, 1953 was later transferred by its author to Schizaea probably because she considered the opening on the holotype to be monolete in nature. The holotype has thickenings at the longitudinal ends, the ridges are unbranched, flat, and few in number. If the ridges are actually discontinuous at the longitudinal ends, and all the grains do not show the "monolete" mark, which could easily be a rupture along one of the furrows, these grains would be more ephedroid than schizaeaceous in nature. However, at present their affinity remains doubtful, and the genus is invalid under Article 34(1) of the International Code of Botanical Nomenclature (1959).

Ephedracites Maljavkina, 1958 and Striainaperturites Pierce, 1961 are junior synonyms of Equisetosporites.

TYPE LOCALITY: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Holotype: Pl. 17, figs. 13-15. Depth 3850 to 3860 feet; Ellerslie Member.

Pl. 17, figs. 10-12. Depth 3850 to 3860 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 17, fig. 10. Slide No. IN3850-3860-3; co-ord. 22.1/54.

Pl. 17, fig. 11. Slide No. Micro. 58; co-ord. 17/39.5.

Pl. 17, fig. 12. Slide No. Micro. 83; co-ord. 14.1/48.2.

Holotype: Pl. 17, figs. 13-15. Slide No. Micro. 82; co-ord. 17.7/48.

Equisetosporites cf. E. ovatus (Pierce) n. comb.

Plate 17, figure 16

1961 Striainaperturites ovatus Pierce, Minnesota Geol. Surv. Bull. 42, p. 45, pl. 3, fig. 80.

DESCRIPTION: Acolpate pollen grains; ellipsoid, narrower at one end; exine two-layered; smooth endexine overlain by a thicker ectexine; ectexinous ridges unbranched, straight, about 4 microns wide in the middle, narrowing at the longitudinal ends, low, gently rounded, running longitudinally, about 12 to 15 in number; furrows narrow, about 1 micron wide, unbranched, straight; ridges coalesce just before reaching the longitudinal ends, so that the furrows do not reach the margin; ectexine thickened at the longitudinal ends.

SIZE RANGE: Longitudinal axis about 54 microns.

Maximum diameter about 28 microns.

Ratio of longitudinal axis to maximum diameter about 1.9.

DISTRIBUTION: Barremian? to Cenomanian. Very rare. In central Alberta a single specimen of this species was recorded from the Ellerslie Member.

REMARKS: This species is very similar to Striainaperturites ovatus Pierce, 1961, but differs in having a slightly larger size, narrower and more numerous ridges. Striainaperturites ovatus has a 47 x 23 microns size, 8 to 9 ridges each about 6 microns in width. As S.ovatus was described on the basis of two specimens only, the range of variation within the species could not have been determined with certainty. Probably the above described specimen comes within the range of variation of this species.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 17, fig. 16. Depth 3046 to 3054 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 17, fig. 16. Slide No. Micro. 232; co-ord. 10.9/41.9.

Equisetosporites albertensis n. sp.

DESCRIPTION: Acolpate pollen grains; ellipsoid, width equal at both the ends; exine two-layered; smooth endexine overlain by a thicker ectexine; ectexinous ridges unbranched, straight, about 10 microns wide in the middle, narrowing at the longitudinal ends, low, gently rounded, running longitudinally, about 12 in number; furrows narrow, about 1 micron wide, unbranched, straight; criss cross pattern of ridges on the illustrated specimen appears to have been produced by the twisting of the grain during fossilization; ridges coalesce just before reaching the longitudinal ends so that the furrows do not reach the margin; a simple unsculptured area where all the ridges fuse is present at the longitudinal ends; ectexine, normally only 1 micron thick, is thickened to about 3 microns at the longitudinal ends.

SIZE RANGE: Longitudinal axis 100 to 115 microns.

Holotype 106 microns.

Maximum diameter 33 to 38 microns.

Holotype 34 microns.

Ratio of longitudinal axis to maximum diameter about 3.1.

DISTRIBUTION: Barremian? Rare. Occurs at only one horizon near the base of the Ellerslie Member in Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.), in central Alberta.

TYPE LOCALITY: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 17, figs. 17, 18. Depth 3850 to 3860 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 17, figs. 17, 18. Slide No. Micro. 81; co-ord. 8.5/39.5.

MARINE MICROPLANKTON

ORDER DINOFLAGELLATA

FAMILY PERIDINIDAE Kofoid

Genus Palaeoperidinium Deflandre, 1934

1934 Palaeoperidinium Deflandre, C.R. Acad. des Sci., 199, pp. 967, 968.

DIAGNOSIS: Fossil vesicle of general peridinous appearance; plated, but tabulation not well enough preserved to allow more precise generic assignment.

Palaeoperidinium Deflandre, 1934 was proposed as a collective group and, therefore, no type species was designated.

Palaeoperidinium cretaceum Pocock, 1962

Plate 18, figure 1

1962 Palaeoperidinium cretaceum Pocock, Palaeontographica B, 111, p. 80, pl. 14, figs. 219-221.

DESCRIPTION: Theca longer than broad; epitheca long and tapering to a point on which a solid apical horn is often present; a spiral equatorial girdle is distinctly developed in the middle; the hypotheca is convex and carries two unequal antapical horns; thecal wall very thin, colourless with no indication of plates or longitudinal furrow; the surface is scabrate to finely granulose.

SIZE RANGE: Length 80 to 95 microns.

Breadth 50 to 70 microns.

Length of the longer antapical horn 12 to 23 microns.

Length of the shorter antapical horn 4 to 8 microns.

DISTRIBUTION: Cretaceous. Abundant. In central Alberta this species occurs in marine sediments of the Clearwater Formation and the lower portion of the Grand Rapids Formation. It is long ranging and may be found also in the marine sediments of the Upper Cretaceous.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 18, fig. 1. Depth 2598 to 2607 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 18, fig. 1. Slide No. Micro. 130; co-ord. 13/42.

Palaeoperidinium granulatum n. sp.

Plate 18, figures 2, 3

DESCRIPTION: Test nearly circular, approximately as long as broad; apical horn is on an average $1/5$ of the total length, solid to partly solid, short and conical, arising abruptly from the epitheca; a spirally winding membraneous structure often present on the apical horn; body distinctly granulose, the equatorial girdle in the middle marked by two prominent lines on which longer spinules are present; no plates or longitudinal furrow are visible; one longitudinal fold and two horizontal folds one on each surface are usually present.

SIZE RANGE: Total length (including apical horn) 96 to 115 microns.

Holotype 100 microns.

Length of the test 80 to 89 microns.

Holotype 82 microns.

Breadth of the test 80 to 88 microns.

Holotype 83 microns.

Length of the apical horn 16 to 26 microns.

Holotype 18 microns.

DISTRIBUTION: Middle Albian. Common. In central Alberta this species

was recorded from the Shale Member of the Clearwater Formation and the lower portion of the Grand Rapids Formation.

REMARKS: Palaeoperidinium is distinguished from the genus Gonyaulax Diesing, 1866 by the absence of precise tabulation and plates in the former. Palaeoperidinium nudum Downie, 1957 can be distinguished from P. granulatum n. sp. by its longer apical horn, which is $\frac{1}{3}$ of the total length of the body, elongated test and smooth transparent wall. P. ventriosum Deflandre, 1935, on the other hand, has a much smaller apical horn compared with the size of the body, and the overall dimensions are smaller than P. granulatum n. sp.

TYPE LOCALITY: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Holotype: Pl. 18, fig. 3. Depth 2598 to 2607 feet; Grand Rapids Formation.

Pl. 18, fig. 2. Depth 2598 to 2607 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 18, fig. 3. Slide No. Micro. 129; co-ord. 13.1/42.1.

Pl. 18, fig. 2. Slide No. Micro. 129; co-ord. 13.1/42.1.

FAMILY GONYAULACIDAE Lindemann

Genus Gonyaulax Diesing, 1866

1866 Goniaulax Diesing, Revision der Prothelminthen, S.-B. Akad. Wissensch. Wien., math. - nat. Kl. 52, p. 287.

1883 Goniaulax polyedra Stein, pl. 4, figs. 7-9.

1911 Gonyaulax polyedra (Stein) Kofoed, Dinoflagellata of the San Diego region. IV, Univ. Calif. Publ. Zool. 8, pp. 187-300, Tables 9-19, 5 figs, (type species).

DIAGNOSIS: Dinoflagellates with plated tests; 3 to 6 apical plates; 0-4

anterior intercalary plates; 6 precingular plates; 6 postcingular plates; 0-1 posterior

intercalary plates; 1 antapical plate (tabulation formula: 3-6', 0-4a, 6'', 6''', 0-1p,

1'''); sutures separating the plates bear high serrated or spinose flanges; longitudinal furrow extends to the apex.

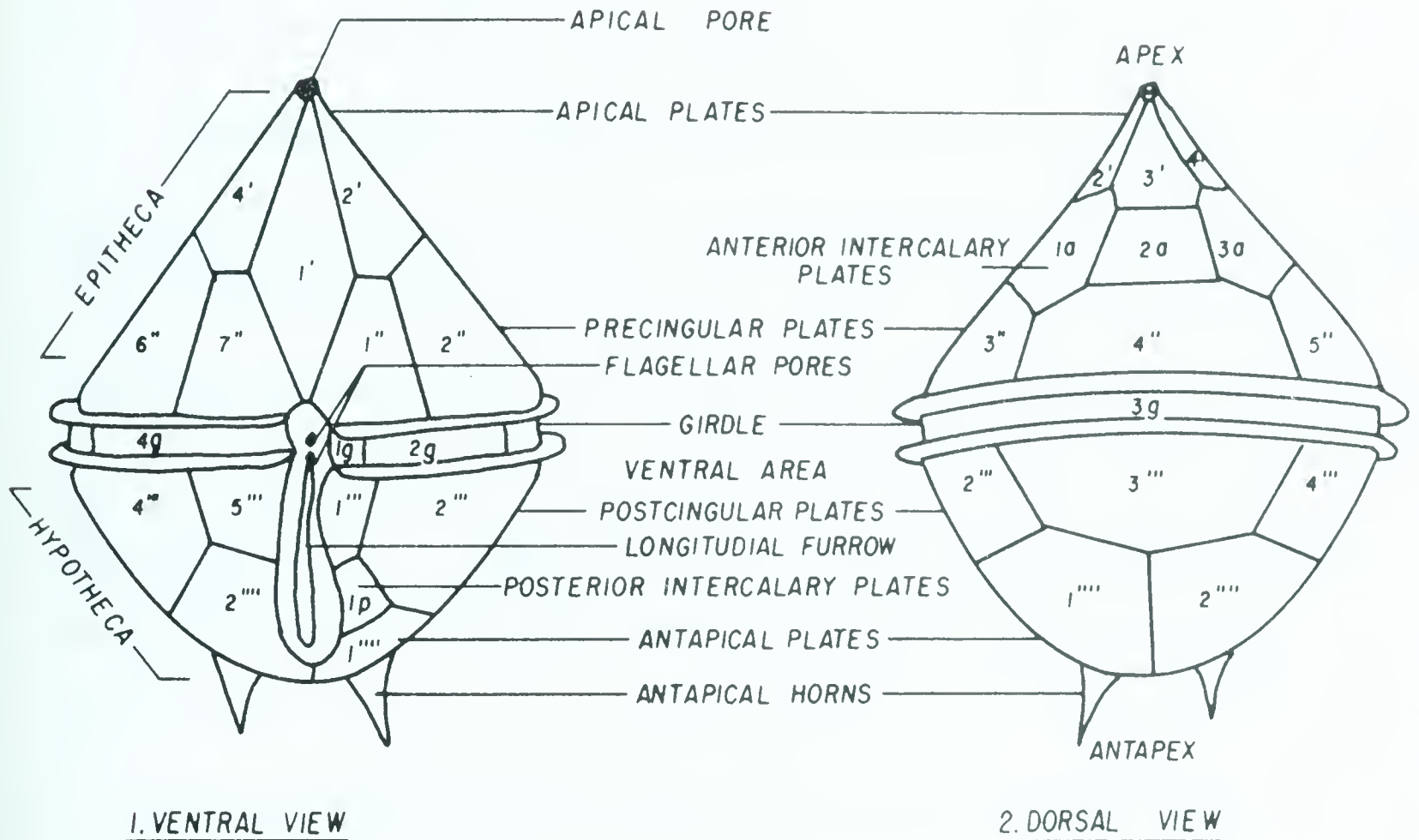


Figure 12. Dinoflagellate terminology and tabulation (after Evitt, 1961).

Symbols used for various plates: Apical plates= ' ; Anterior intercalary plates= a ; Precingular plates= '' ; Girdle plates= g ; Postcingular plates= ''' ; Posterior intercalary plates= p ; Antapical plates= '''' .

Gonyaulax cf. G. jurassica Deflandre, 1938

Plate 18, figure 4

1938 Gonyaulax jurassica Deflandre, C.R. Acad. Sci., 206, p. 688, fig. 2.

DESCRIPTION: Test ellipsoidal; a well developed apical horn, which is not as long as in G. jurassica; a well defined spiral equatorial furrow, tabulation pattern not completely established but appears to be 3', 6'', 6''', lp, 1''''; the

sutures have high serrated flanges.

SIZE RANGE: Total length 112 microns.

Apical horn 20 microns.

Width of body 98 microns.

DISTRIBUTION: Oxfordian to Middle Albian? Very rare. In central Alberta only one specimen was recorded near the base of the Grand Rapids Formation. Probably it is a reworked specimen from the Jurassic. To date, it has been reported only from the Upper Jurassic sediments of United States, Europe and Australia.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 18, fig. 4. Depth 2607 to 2616 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 18, fig. 4. Slide No. Micro. 185; co-ord. 11.5/39.5.

ORDER HYSTRICHOSPHERIDEA Eisenack, 1938

FAMILY HYSTRICHOSPHERIDAE (Wetzel, 1933) emend. Deflandre, 1937

Genus Hystrichosphaeridium Deflandre, 1937 restr. Eisenack, 1958

- 1838 Xanthidium tubiferum Ehrenberg, Abh. Wiss. Zu. Berlin Pt. 1, fig. 19.
- 1933 Hystrichosphaera tubifera Wetzel, Palaeontographica A, 77, pp. 86-87, pl. 4, fig. 16.
- 1937 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre, Microfossiles des Silex cretaces, Part II, Ann. Paleont., 26, p. 96, pl. 13, figs. 2, 4, 5, (type species).
- 1958 Hystrichosphaeridium Deflandre restr. Eisenack, Neues. Jb. Geol. Palaont., vol. 106, no. 3, pp. 399-400.

DIAGNOSIS: Hystrichosphaeridae with spherical to oval non-plated central vesicle bearing numerous well disposed, generally similar, often funnel-shaped processes, widening and opening towards the outer end.

Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre, 1937

Plate 18, figure 5

- 1838 Xanthidium tubiferum Ehrenberg, Abh. Wiss. Zu. Berlin Pt. 1, fig. 19.
 1933 Hystrichosphaera tubifera Wetzel, Palaeontographica A, 77, pp. 86-87, pl. 4, fig. 16.
 1937 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre, Microfossiles des Silex cretaces, Part II, Ann. Paleont., 26, p. 96, pl. 13, figs. 2, 4, 5, (type species).
 1958 Hystrichosphaeridium Deflandre restr. Eisenack, Neues, Jb. Geol. Palaont., vol. 106, no. 3, pp. 399-400.

DESCRIPTION: Vesicle circular to ellipsoidal in outline with smooth surface; the processes are tubular, narrow, hollow and of uniform width except at the outer ends where they broaden out into a funnel-shaped structure, and are open; processes are long in comparison with vesicle diameter; the lips of the processes are irregular and bear recurved spines.

SIZE RANGE: Diameter of vesicle 34 microns.

Length of processes 20.4 microns.

Width of processes at the base 3 microns.

Width of processes at the apex 22 microns.

Number of processes 10.

DISTRIBUTION: Barremian to Senonian. Rare. In western Canada this species ranges from the Upper Mannville to the Upper Colorado strata.

AFFINITY: Some hystrichospheres are perhaps dinoflagellate cysts with an apical archeopyle, in which both rupture lines and processes indicate the characteristic tabulation of an original outer wall that has not been preserved. The processes are interpreted as structures that braced the cyst against a now missing outer wall. Evitt

(1961) has illustrated the apical archeopyle where the cyst has ruptured, and also polygonal areas on the wall of the cyst itself which reflect the characteristic tabulation of the original outer wall that has not been preserved. However, this tabulated outer wall has not yet been found to substantiate this very plausible hypothesis.

Probably not all hystrichospheres could be included among the dinoflagellates. They are most probably a polyphyletic group representing the eggs, cysts, tests of bryozoans, desmids, crustaceans and flagellates. Their similarity in external morphology does not indicate a close genetic relationship. Deflandre (1947) has presented evidence in favour of polyphyletic relations of hystrichospheres. Eisenack (1954), however, believes in monophyletic origin of hystrichospheres and treats them as a single group of related organisms which have shown evolutionary changes with time.

REMARKS: Eisenack (1958) restricted the genus Hystrichosphaeridium to only those forms in which the processes are open at the outer ends. He created a new genus, Baltisphaeridium, to include forms whose processes are closed at the outer ends. Hystrichosphaeridium can be distinguished from Hystrichosphaera by the spiral girdle-like structure and conspicuous polygonal areas present on the vesicle of the latter.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 18, fig. 5. Depth 2095 to 2098 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 18, fig. 5. Slide No. Micro. 127; co-ord. 10.5/40.5.

Hystrichosphaeridium albertense Pocock, 1962

Plate 18, figures 6, 7

1962 Hystrichosphaeridium albertense Pocock, Palaeontographica B, 111, 1-3, p. 71, pl. 15, figs. 226-227.

DESCRIPTION: Vesicle thin, smooth and circular in outline; the processes are trumpet-shaped being narrow at the base and broadening out continuously towards the apex; processes are hollow opening at the apex and are long in comparison with the vesicle diameter; the lips of the processes are irregular and frayed.

SIZE RANGE: Diameter of vesicle 44 (48) 52 microns.

Length of processes 22 (27.5) 33 microns.

Width of processes at base 3 (5) 10 microns.

Width of processes at the apex 14 (23) 32 microns.

Number of processes 12 to 16.

DISTRIBUTION: Barremian? to Middle Albian. Rare. In central Alberta this species was found in the Wabiskaw Member. In the Northwest Territories it has been reported from the Garbutt Formation (Pocock, 1962).

REMARKS: This species differs from Hystriosphæridium salpingophorum Deflandre in having a larger size, more complex lips on the processes, and more rapid widening of the processes towards the apex.

LOCALITY OF FIGURED SPECIMENS: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 18, fig. 6. Depth 2095 to 2098 feet; Wabiskaw Member.

Pl. 18, fig. 7. Depth 2098 to 2101 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 18, fig. 6. Slide No. Micro. 160; co-ord. 11.4/38.2.

Pl. 18, fig. 7. Slide No. Micro. 161; co-ord. 10.1/36.1.

Hystriosphæridium irregulare Pocock, 1962

Plate 19, figures 1-3

1962 Hystriosphæridium irregulare Pocock, Palaeontographica B, 111, 1-3, pp. 71-72, pl. 15, figs. 228-229.

DESCRIPTION: Vesicle thin, smooth and circular in outline; the processes are funnel-shaped, narrow to very wide and generally variable in shape; processes are hollow and open at the apex; lips of the processes wide and irregular, serrate with serration often extending down the body of the processes in irregular manner, lips frequently spinose.

SIZE RANGE: Diameter of vesicle about 63 microns.

Length of processes about 41 microns.

Width of processes at base 3 to 8 microns.

Width of processes at apex 14 to 36 microns.

Number of processes 12.

DISTRIBUTION: Barremian? to Middle Albian. Common. In central Alberta this species was found in the Wabiskaw Member and the Shale Member of the Clearwater Formation. In the Northwest Territories it has been reported from the Garbutt Formation by Pocock (1962).

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 19, figs. 1-3. Depth 2055 to 2065 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 19, figs. 1-3. Slide No. Micro. 88; co-ord. 8.9/36.5.

Genus Baltisphaeridium Eisenack, 1958

- 1931 Hystrichosphaeridium longispinosum Eisenack, Neue Mikrofossilien des baltischen Silurs. I., Palaeontol. Zeit., 13, pp. 74-118, Berlin.
- 1958 Baltisphaeridium longispinosum (Eisenack) Eisenack, Mikroplankton aus dem norddeutschen Apt, Neues Jb. Geol. Palaont., vol. 106, p. 398, (type species).

DIAGNOSIS: Hystrichospheres with globular to oval body devoid of any plates, and bearing numerous processes which may be branched or unbranched, but are always

hollow and closed at the outer end.

Baltisphaeridium longispinosum (Eisenack) Eisenack, 1958

Plate 19, figure 5

- 1931 Hystriosphæridium longispinosum Eisenack, Neue Mikrofossilien des baltischen Silurs. I., Palaeontol. Zeit., 13, pp. 74-118, Berlin.
- 1958 Baltisphaeridium longispinosum (Eisenack) Eisenack, Mikroplankton aus dem norddeutschen Apt, Neues Jb. Geol. Paläont., vol. 106, p. 398, (type species).

DESCRIPTION: Vesicle spherical thin-walled with some circular foldings caused by the flattening of the sphere; about 33 very thin and elongated hollow processes, tapering and closed at the outer end, distributed over the whole surface of the sphere; the processes are longer than the radius of the test, and broaden slightly at the base.

SIZE RANGE: Diameter of the vesicle 48 microns.

Length of the processes about 32 microns.

Width of the processes 2 to 3 microns.

Number of processes about 33.

DISTRIBUTION: Probably reworked from Ordovician sediments. In central Alberta, a single specimen of this species was found in the upper portion of the Grand Rapids Formation in the Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

REMARKS: Prof. Eisenack, who has seen the photograph of this specimen, is of the opinion that it is Baltisphaeridium longispinosum forma filifera which was described by him from the Ordovician sediments of Estonia. It is almost certain that this specimen has been reworked from older Palaeozoic sediments. However, the

number of processes in B.longispinosum which is restricted to less than 25 in number does not apply here, because this specimen has 33 processes. It is here recommended that B.longispinosum should be emended so that specimens possessing more than 25 processes can be included in it.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp 55, R. 15, W. 4th Mer.).

Pl. 19, fig. 5. Depth 1816 to 1826 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 19, fig. 5. Slide No. Micro. 145; co-ord. 10/39.5.

Baltisphaeridium cf. B. neptuni Eisenack, 1958

Plate 19, figures 6, 7

1958 Baltisphaeridium neptuni Eisenack, Mikroplankton aus dem norddeutschen Apt, Neues Jb. Geol. Palaont., vol. 106, p. 399, pl. 26, figs. 7-8.

DESCRIPTION: Vesicle is thin-walled, spherical to oval, bearing a few cylindrical to slightly conical processes with broad bases which are thin-walled, hollow and closed at the outer ends, bifurcating at the tips into three (rarely 2 or 4) divergent, widely spaced, pointed and tapering spines; length of the processes is about 1/3 the diameter of the vesicle.

SIZE RANGE: Total diameter of the specimen 60 microns.

Diameter of the vesicle 40 microns.

Length of the processes 12 microns.

Width of the processes at base 7 microns.

Width of the processes at apex 1.5 microns.

Length of spines 2.5 microns.

Number of processes about 15.

DISTRIBUTION: Aptian to Middle Albian. Very rare. In central Alberta only one specimen was recorded from the Shale Member of the Clearwater Formation. In Europe this species has been recorded from the Aptian of northern Germany (Eisenack, 1958).

AFFINITY: Probably a dinoflagellate cyst.

REMARKS: The Canadian specimens differ from the forms described by Eisenack in having shorter processes. However, in his description Eisenack states that "the processes are about $1/2$ the diameter of the vesicle or somewhat less". Although the diameter of the vesicle comes within the size range given by Eisenack, the total diameter of the specimen is about 15 microns less than the minimum. This is because of shorter processes. In other respects the form described above is close to Baltisphaeridium neptuni Eisenack, 1958, but not identical.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 19, figs. 6, 7. Depth 2717 to 2725 feet; Clearwater Formation,
Shale Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 19, figs. 6, 7. Slide No. Micro. 184; co-ord. 11.5/40.5.

Baltisphaeridium sp.

Plate 19, figure 8

DESCRIPTION: Vesicle oval, thin-walled; processes short, numerous, thin, repeatedly and irregularly branched distally, distributed all over the body.

SIZE RANGE: Total diameter of the specimen 37 microns.

Length of the vesicle 30 microns.

Breadth of the vesicle 25 microns.

Length of the processes 3 microns.

DISTRIBUTION: Middle Albian. Rare. In central Alberta this species was recorded from the Clearwater and the Grand Rapids Formations.

REMARKS: Baltisphaeridium multispinosum n. sp. and Baltisphaeridium sp. have been placed in the genus Baltisphaeridium rather than Micrhystridium, because the diameter of the vesicle is larger than 20 microns. According to the generic diagnosis, Micrhystridium has a vesicle which is less than 20 microns.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 19, fig. 8. Depth 2717 to 2725 feet; Clearwater Formation,
Shale Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 19, fig. 8. Slide No. Micro. 132; co-ord. 5.9/42.5.

Baltisphaeridium multispinosum n. sp.

Plate 20, figures 1, 2

DESCRIPTION: Vesicle circular, thin-walled; length of processes about 1/4 of the diameter of the body, unbranched, thin, tapering and closed at the outer end, broadening slightly towards the base; vesicle densely covered with processes distributed all over the surface; some of the processes may bifurcate at the tips.

SIZE RANGE: Total diameter of the specimens 62 to 74 microns.

Holotype 62 microns.

Diameter of the vesicle 40 to 50 microns.

Holotype 41 microns.

Length of the processes 10 to 15 microns.

Holotype 10 microns.

Width of the processes 0.5 to 1 micron.

Holotype 1 micron.

DISTRIBUTION: Middle Albian. Abundant. In central Alberta this species

is abundant in the Upper Mannville marine sediments.

TYPE LOCALITY: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Holotype: Pl. 20, fig. 1.	Depth 2098 to 2101 feet;	Wabiskaw Member.
Pl. 20, fig. 2.	Depth 2098 to 2101 feet;	Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 20, fig. 1.	Slide No. Micro. 135;	co-ord. 9.8/40.9.
Pl. 20, fig. 2.	Slide No. Micro. 135;	co-ord. 12.3/38.1.

Genus Veryhachium (Deunff, 1954) Deunff, 1958

- 1954 Veryhachium trisulcum Deunff, C.R. somm. Soc. Geol. Fr., pp.305-307, (type species).
- 1958 Veryhachium trisulcum Deunff, Bull. Soc. Geol. et Min. Bretagne, Nouvelle Serie, Fascicule 2, p. 27, pl. 1, figs. 4, 13.

DIAGNOSIS: Outline globular, ovoid, subpolyhedral or triangular with concave to convex margin; most common forms are triangular or prismatic with three and sometimes four simple long processes which are hollow with closed tips and are connected with the central body; the number of processes is always less than ten; as the animal tends to grow spherical there is a corresponding increase in the number of processes.

Veryhachium reductum (Deunff, 1958) Jekhowsky, 1961

Plate 20, figure 3

- 1958 Veryhachium trisulcum (Deunff, 1954) var. reductum Deunff, Bull. Soc. Geol. et Min. Bretagne, Nouvelle Serie, Fascicule 2, p. 27, pl. 1, figs. 1, 3, 8, 11.
- 1961 Veryhachium reductum (Deunff, 1958) Jekhowsky, Rev. de Micropaleontologie, vol. 3, no. 4, pp. 210-212, pl. 2, figs. 22-44.

DESCRIPTION: Central body triangular; sides slightly convex; three long processes, one at each apex; processes acicular, rigid, opening into the central

body and closed at their extremity. It is closest in appearance to Veryhachium reductum (Deunff, 1958) Jekhowsky, 1961 forma reductum. This species was found to be polymorphic by Jekhowsky (1961) who distinguished three "forms" corresponding to three intergrading but distinct morphologic groups. However, in the presence of intermediate forms, such distinctions are not apparent.

SIZE RANGE: Width between the base of two processes 35 to 40 microns.

Length of the processes 15 to 25 microns.

Width of the processes at the base 2 to 4 microns.

DISTRIBUTION: Ordovician to Cenomanian. Rare. In central Alberta this species was found to be common only in the upper part of the Grand Rapids Formation, between the depths of 1801 and 1836 feet in the Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.). It has been reported from the Ordovician of Brittany, France, Ordovician to Lower Carboniferous of Sahara, Permo-Trias of Yugoslavia, Tunisia, Libya, Madagascar, and the Soviet Arctic; the Triassic of northwestern Australia; Aptian to Cenomanian of Perth Basin (Osborne Formation) and the Carnarvon Basin of Western Australia (Cookson and Eisenack, 1962).

AFFINITY: The affinity of this genus is doubtful. Deunff (1958) and most of the other workers are of the opinion that it belongs to the family Hystrichosphaeridae. Baschnagel (1942), however, considers it to be an alga belonging to the Class Chlorophyceae. Probably a cyst.

REMARKS: There are some differences in size of specimens described by various authors. According to Deunff (1958) the size range is 20 to 40 microns; Jekhowsky (1961) gives a size range from 10 to 25 microns; whereas, Cookson and

Eisenack (1962) have specimens with a size range from 44 to 60 microns. Perhaps these are not the same species, and specific distinctions could be made in the future according to size groupings.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 20, fig. 3. Depth 1816 to 1826 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 20, fig. 3. Slide No. Micro. 116; co-ord. 9.2/46.

Veryhachium irregulare forma subhexahedron Jekhowsky, 1961

Plate 20, figure 4

1961 Veryhachium? irregulare forma subhexahedron Jekhowsky, Rev. de Micro-paleontologie, vol. 3, no. 4, pp. 208-210, pl. 1, figs. 1-3.

DESCRIPTION: Outline of the central body subhexahedral, convex, with six appendages, one at each apex; in flattened condition the shape is roughly quadrangular, with four of the appendages showing on the four corners and the remaining two appendages on the front and back surfaces; the appendages are conical and hollow, opening into the central body and closed at the extremity; the form and dimensions of these appendages may be somewhat variable in the same individual. This species is also considered polymorphic by Jekhowsky (1961), and he has divided it into four main "forms".

SIZE RANGE: Diameter of the central body 20.4 microns.

Length of processes 10 microns.

DISTRIBUTION: Permian to Middle Albian? Very rare. In central Alberta this species was recorded only from the upper portion of the Grand Rapids Formation, between the depths of 1816 and 1826 feet in the Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.). It has also been reported from the Permo-

Trias of Brazil and Yugoslavia, and from the Anisian and the Norian of the Soviet Arctic (Kara-Murza, 1957).

AFFINITY: Probably a cyst.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 20, fig. 4. Depth 1816 to 1826 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 20, fig. 4. Slide No. Micro. 149; co-ord. 11.2/42.

INCERTAE SEDIS

Genus Pseudoceratium Gocht, 1957

1957 Pseudoceratium pelliiferum Gocht, Palaontologische Zeitschrift 31, pp. 166-168, pl. 18, figs. 1-2, (type species).

DIAGNOSIS: Theca of organic substance (shaped like a peridinin), characterized by several elongated horns; plates, girdle system and furrow are absent; theca smooth or covered with short processes, apical part frequently separated by an irregular line of rupture.

Pseudoceratium pelliiferum Gocht, 1957

Plate 20, figures 5, 6

1957 Pseudoceratium pelliiferum Gocht, Palaontologische Zeitschrift 31, pp. 166-168, pl. 18, figs. 1-2.

DESCRIPTION: Theca flattened; outline asymmetrically triangular with convex sides, longer than broad, with a strongly developed apical horn, and two shorter, unequal, and widely divergent antapical horns, one of which may be much reduced or absent; the

apical horn and the larger of the antapical horns are very often in one axis; the body is more or less densely covered with rounded, blunt, and setaceous processes, the distal end of which are broadened; the setae may be single, or two or more setae may be fused at the base; they are not developed uniformly and are longer on the horns; the setae are at right angles to the theca on the main part of the body, but closer to the horns they are at acute angles thus presenting a serrated outline, the setae are probably hollow; the apical portion of the cell is sometimes detached along a line of weakness which is above the equatorial zone and probably represents an apical archeopyle, the line of rupture is irregular.

SIZE RANGE: Length of theca 75 to 95 microns.

Breadth of theca 60 to 85 microns.

Length of apical horn 20 to 50 microns.

Length of antapical horns about 11 microns
(not completely preserved).

Length of spines 5 microns.

DISTRIBUTION: Valanginian to Middle Albian. Common. In central Alberta this species occurs in the marine sediments of the Clearwater and the Grand Rapids Formations. In the Northwest Territories it has been reported from the Garbutt Formation (Pocock, 1962). This species was first described from Valanginian to Aptian horizons of northwestern Europe.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 20, fig. 5. Depth 2607 to 2616 feet; Grand Rapids Formation.

Pl. 20, fig. 6. Depth 2598 to 2607 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 20, fig. 5. Slide No. FA2607-2616-1; co-ord. 10/32.

Pl. 20, fig. 6. Slide No. Micro. 128; co-ord. 16/37.

Pseudoceratium gochtii Pocock, 1962

Plate 20, figure 7

1962 Pseudoceratium gochtii Pocock, Palaeontographica B, 111, p. 79, pl. 14, figs. 213, 214.

DESCRIPTION: Theca roughly ellipsoidal, longer than broad; equatorial girdle, plates and longitudinal furrow not developed; wall thin, smooth, hyaline; apex convex, terminated by a long solid apical horn which is very variable in length; two antapical horns are of more or less equal length.

SIZE RANGE: Total length of body (including the horns) 93.5 microns.

Length of theca 59.4 microns.

Breadth of theca 34 microns.

Length of apical horn 20.5 microns.

Length of antapical horns 10.2 and 13.6 microns.

DISTRIBUTION: Cretaceous. Rare. Only one specimen was recorded from the Shale Member of the Clearwater Formation in central Alberta.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 20, fig. 7.	Depth 2782 to 2785 feet;	Clearwater Formation, Shale Member.
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REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 20, fig. 7.	Slide No. Micro. 192;	co-ord. 10.8/40.2.
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Genus Canningia Cookson and Eisenack, 1960

1960 Canningia reticulata Cookson and Eisenack, Palaeontology, vol. 2, pt. 2, p. 251, pl. 38, fig. 1, (type species).

DIAGNOSIS: Shell flattened, roughly five-sided to almost circular with a slight apical prominence and broadly indented base; basal projections (corresponding

to antapical horns) are either equal or unequal and frequently differ slightly in shape; an equatorial girdle is either absent or faintly indicated both on the surface or by re-entrant angles at the sides; the shell opens by a proximal break which results in the complete detachment of the apical region.

Canningia colliveri Cookson and Eisenack, 1960

Plate 20, figure 8

- 1960 Canningia colliveri Cookson and Eisenack, Palaeontology, vol. 2, pt. 2, p. 251, pl. 38, figs. 3, 4.
 1962 Palaeohystrichophora brevispinosa Pocock, Palaeontographica B, 111, p. 81, pl. 14, figs. 222-223.

DESCRIPTION: Theca somewhat longer than broad, widest at equator; apical projection conical, prominent; two antapical projections always unequal, with one projection invariably longer and sharper; antapical projections less prominent than the apical projection; equatorial girdle not seen on the specimens examined; wall thin and closely to sparsely spinulate; spines short on the body but 3 to 5 microns long on the apical and antapical projections; every specimen examined shows a rupture below the base of the apical projection which represents the apical archeopyle; the theca opens by the complete detachment of the apical region at the place of rupture; Canningia probably represents a motile stage (Evitt, 1961).

SIZE RANGE: Length 102 (114) 127 microns.

Breadth 68 (80.5) 92 microns.

Length to breadth ratio 1.29 (1.42) 1.61.

DISTRIBUTION: Aptian to Middle Albian. Common. In central Alberta this species makes its first appearance in the Wabiskaw Member where it is abundant.

Its occurrence in the Shale Member of the Clearwater Formation is abundant to rare. It has been reported from the Garbutt Formation of Northwest Territories, by Pocock (1962) and from the Aptian Stage of northern Queensland and Carnarvon Basin of Western Australia by Cookson and Eisenack (1960). It is an important stratigraphic marker.

REMARKS: The stratigraphic distribution of Palaeohystrichophora brevispinosa Pocock, 1962 is the same as for the specimens described above as Canningia colliveri Cookson and Eisenack, 1960.

The holotype of C. colliveri is 107 microns long and 100 microns broad, and the paratype is 106 microns long and 90 microns broad. The dimensions of P. brevispinosa Pocock, 1962 are 110 (114) 120 microns long and 69 (98) 110 microns broad. The dimensions as well as the length to breadth ratio of P. brevispinosa are well within the range of variation in C. colliveri. The equatorial girdle is also shown faintly by some specimens of C. colliveri. The body of the paratype is spinulate and suggests a variation both in length as well as density of the spines. Both C. colliveri as well as P. brevispinosa have unequal, short, blunt antapical processes. The genus Palaeohystrichophora has typically fusiform shape and the hypotheca is terminated by a single antapical process. Therefore, P. brevispinosa Pocock, 1962 has been transferred to C. colliveri Cookson and Eisenack, 1960 with which it is identical.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 20, fig. 8. Depth 2085 to 2095 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 20, fig. 8. Slide No. Micro. 133; co-ord. 10.2/39.5.

- 1933 Ceratium (Euceratium) operculatum Wetzel, Palaeontographica A, 77, p. 170, pl. 2, figs. 21, 22.
- 1935 Odontochitina silicorum Deflandre, Bulletin Biologique, 69, p. 234, pl. 9, figs. 8-10.
- 1955 Odontochitina operculata (Wetzel) Deflandre and Cookson, Austral. J. Marine and Freshwater Res. 6: 291, pl. 3, figs. 5, 6, (type species).
- 1962 Odontochitina silicorum Deflandre in Pocock, Palaeontographica B, 111, p. 78, pl. 14, figs. 211, 212.

DIAGNOSIS: Dinoflagellate cyst with chitinous wall; body globular, with one long apical and two antapical horns; an apical archeopyle is marked by a line of weakness below the apex which divides the body into two unequal parts; an inner wall can be distinctly seen at the horn bases within the outer one, indicating that it is a cyst within a cyst; the absence of any trace of a girdle or tabulation, and the entirely smooth wall suggests that it is a cyst, rather than the theca of a motile stage.

Odontochitina operculata (Wetzel) Deflandre, 1955

Plate 20, figure 9

- 1933 Ceratium (Euceratium) operculatum Wetzel, Palaeontographica A, 77, p. 170, pl. 2, figs. 21, 22.
- 1935 Odontochitina silicorum Deflandre, Bulletin Biologique, 69, p. 234, pl. 9, figs. 8-10.
- 1955 Odontochitina operculata (Wetzel) Deflandre and Cookson, Austral. J. Marine and Freshwater Res. 6: 291, pl. 3, figs. 5, 6.
- 1962 Odontochitina silicorum Deflandre in Pocock, Palaeontographica B, 111, p. 78, pl. 14, figs. 211, 212.

DESCRIPTION: Dinoflagellate cyst with thin chitinous wall, entirely smooth, hyaline, with no trace of an equatorial girdle or tabulation; body elongated oval in polar outline and circular in equatorial outline; an apical archeopyle is marked by a line of weakness close to the base of the apical horn which divides the body into two unequal parts; the body has one long apical and two antapical horns; one antapical

horn is in direct axial continuation of the lower part of the body, while the other one branches off from near the equator; an inner wall can be seen at the horn bases, indicating that it is a cyst within a cyst; a very large proportion of specimens are broken into two parts along the line of weakness.

SIZE RANGE: Total length 220 to 400 microns.

Body length 68 to 100 microns; width 35 to 60 microns.

Apical horn length 100 to 200 microns.

Antapical horns length 90 to 150 microns; 50 to 100 microns.

DISTRIBUTION: Hauterivian to Upper Cretaceous. Abundant. In western Canada this species ranges from the Clearwater Formation to the Colorado Formation. It has been recorded from the Hauterivian to the Upper Cretaceous in northwestern Europe and from the Albian to the Lower Turonian in Australia.

REMARKS: Pocock (1962) has treated this genus as a representative of a motile stage. In this connection he mentions an "equatorial groove not always well marked although there is always a line of weakness around the equator". This does not appear to be the case. In specimens examined, the line of weakness is more apical in position, and perhaps represents an apical archeopyle rather than an equatorial groove. The genus Odontochitina is very similar in nature to Wetzeliella, which is perhaps a cyst within a cyst.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 20, fig. 9, 10.

Depth 2717 to 2725 feet;

Clearwater Formation,
Shale Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 20, fig. 9.

Slide No. Micro. 164;

co-ord. 11/41.

Pl. 20, fig. 10.

Slide No. Micro. 131;

co-ord. 16.5/46.5.

MEGASPORES

Nearly all the megaspores prior to 1954 were placed in a single genus Triletes, a practice which Harris (1961) is still following. Potonie and Kremp (1954) and Potonie (1956 and 1958a) revised the megaspore genera under Triletes and created numerous genera, based purely on spore morphology. Potonie (1956), however, rejected the old genus Triletes, and raised it to the level of Turma (Division) and introduced Trileites (Erdtman, 1945) Potonie, 1956 as a form-genus. This does not appear to be justified as Triletes (Reinsch, 1884) emend. Schopf, 1938 has priority as a form-genus.

Chaloner (1959, p. 322) and Harris (pers. comm.) both feel that this purely morphographic classification by Potonie and Kremp (1954) and Potonie (1956) cuts across known biological relationships. Chaloner gives the example of spores borne by Sigillaria which were placed under two distinct form-genera on the basis of difference in wall decoration. The same is true of the natural genus Selaginella. This problem is of course present in the case of microspores also. However, in general, attention should be paid to the studies made on spore containing megasporangiate fructifications while proposing a fossil megaspore classification and the groupings should be as close as possible to the natural system. This has its limitations in so far as in most cases the knowledge of natural relationships is not sufficient to achieve this ideal. At present there is a tendency towards increasing multiplicity of megaspore genera, most of which as pointed out by Chaloner in the case of Sigillaria, are based only on characters of specific value. This results in producing an exaggerated impression of the degree of difference between different

assemblages. There is an obvious necessity to circumscribe the megaspore genera as close as possible to the natural system.

On the other hand, some splitting of the rather diversified entities that had accumulated under the old genus Triletes is clearly desirable. Therefore, in this work the genus Triletes is used as emended by Schopf (1938), and the form-genera Horstisporites, Verrutrites, Erlansonisporites, Maexisporites, Dijkstraisporites and Arcellites all of which had been previously placed in the old genus Triletes, are distinguished from one another.

Genus Triletes (Reinsch, 1881) Schopf, 1938

- 1881 Triletes Reinsch, Neue Untersuchungen über die Mikrostruktur der Steinkohle des Carbon, der Dyas und Trias, Leipzig.
- 1884 Triletes Reinsch, Micro-Palaeophytologia formationis carboniferae: vol. 1, Erlangae, Germania, Theo. Krieger, pp. vii + 80, pls. 1-66.
- 1886 Triletes I Bennie and Kidston, Royal Phys. Soc. Edinburgh Proc., vol. 9, p. 107, pl. 111, figs. 1a, b.
- 1932 Sporonites reinschi Ibrahim, Neues Jahrb, Beilage - Band 67, Abt. B, p. 449, pl. 17, fig. 28.
- 1933 Laevigati-sporites reinschi (Ibrahim) Ibrahim, Sporenformen des Aegirhorizonts, Dissertation, Berlin, p. 18, pl. 4, fig. 28.
- 1934 Reticulati-sporites reinschi (Ibrahim) Loose, Inst. Palaobot. Arb., vol. 4, no. 3, p. 157.
- 1934 Sporites primus Wicher, Inst. Palaobot. Arb., vol. 4, no. 4, p. 169.
- 1938 Triletes reinschi (Ibrahim) Schopf, Illinois Geol. Survey, Rept. Inv. 50, pp. 0-73, (type species).

DIAGNOSIS: Megaspores; radially symmetrical; equatorial outline more or less circular; proximal side marked by triradiate sutures or cracks separating three equal contact faces; arcuate ridges connecting the ends of the rays may be present; distal surface smooth or slightly granulate to rugulate, ornamentation generally less well developed on proximal than on distal surface; equatorial diameter exceeding 150 microns; usually very large, up to or more than 3 mm.

Triletes persimilis Harris, 1935

Plate 21, figure 1

1935 Triletes persimilis Harris, Meddelelser om Greenland, Bd. 112, Nr. 2, p. 165, pl. 25, fig. 4.

DESCRIPTION: Spore more or less circular; spore wall often sunken; proximal side marked by a very distinct triradiate crack separating three equal contact faces, the spore often split into three equal portions along these cracks; triradiate ridge present on the margin of the cracks, in undehisced specimens the triradiate ridge can be seen extending up to $3/4$ the radius of the spore; however, in dehisced specimens where the cracks appear along the triradiate ridge, the arms of the ridge extend up to the margin of the spore; spore wall smooth; arcuate ridges absent.

SIZE RANGE: Equatorial diameter 400 to 600 microns.

Width of the triradiate ridges 15 microns.

Height of the triradiate ridges 10 to 20 microns.

Thickness of the exine 20 microns.

DISTRIBUTION: Rhaetic-Liassic to Senonian. Rare. In central Alberta this species has so far been found only in the Grand Rapids Formation (Middle Albian). However, in other parts of the world it has been recorded from Rhaetic-Liassic sediments of east Greenland (Harris, 1935), the Wealden of England (Dijkstra, 1951) and the Senonian of Netherlands (Dijkstra, 1949).

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 21, fig. 1. Depth 1816 to 1826 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 21, fig. 1. Slide No. Mega. 27; co-ord. 11/68.

Triletes sp. A

Plate 21, figure 2

DESCRIPTION: Trilete megaspore; equatorial outline circular; surface smooth; proximal side marked by triradiate ridges 60 to 100 microns high at their extremities, which are reduced to a height of only 20 microns towards the proximal pole where they join; length of the triradiate ridges about 2/3 of the spore radius; the laesurae can be seen as cracks on the triradiate ridges.

SIZE RANGE: Equatorial diameter 641 microns.

DISTRIBUTION: Barremian? Very rare. In central Alberta a single specimen of this species was recorded from the middle of the Ellerslie Member.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 21, fig. 2. Depth 3111 to 3120 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 21, fig. 2. Slide No. Mega. 90; co-ord. 14/34.5.

Triletes sp. B.

Plate 21, figure 3

DESCRIPTION: Trilete megaspore; equatorial outline circular; surface coarsely granular; proximal side marked by raised and sinuous triradiate ridges which nearly reach the equator; laesurae can be seen as cracks on the triradiate ridges.

SIZE RANGE: Equatorial diameter 397 microns.

DISTRIBUTION: Barremian? Very rare. In central Alberta a single specimen of this species was recorded from the middle of the Ellerslie Member.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 21, fig. 3. Depth 3111 to 3120 feet; Ellerslie Member.
 REPOSITORY: Res. Coun. Alberta Palynological Type Coll.
 Pl. 21, fig. 3. Slide No. Mega. 89; co-ord. 10/37.

Genus Horstisporites Potonie, 1956

- 1951 Triletes reticuliferus Dijkstra, Netherlands, Meded. Geol. Stichting, new ser.,
 no. 5, p. 10, pl. 2, figs. 12, 13.
 1956 Horstisporites reticuliferus (Dijkstra) Potonie, Beih. Geol. Jahrb., vol. 23,
 pp. 44, 45, pl. 5, fig. 51, (type species).

DIAGNOSIS: Trilete megaspores; equatorial outline circular to faintly sub-
 triangular, trilete mark about half the radius of the spore or longer, contact faces
 and arcuate ridges not distinguishable, entire exine alveolar or reticulate.

Horstisporites reticuliferus (Dijkstra) Potonie, 1956

Plate 21, figures 4, 5

- 1951 Triletes reticuliferus Dijkstra, Netherlands, Meded. Geol. Stichting, new ser.,
 no. 5, p. 10, pl. 2, figs. 12, 13.
 1956 Horstisporites reticuliferus (Dijkstra) Potonie, Beih. Geol. Jahrb., vol. 23,
 pp. 44, 45, pl. 5, fig. 51.

DESCRIPTION: Trilete megaspore; body spherical; triradiate ridges somewhat
 flexuous and extending only up to 1/2 of the spore radius, about 120 microns high and
 20 microns wide at the top, widening towards the base; contact faces and arcuate
 ridges not distinguishable; entire surface heavily reticulate with flap-like muri 30 to
 40 microns high and irregularly outlining the lumina; muri 15 to 20 microns wide;
 reticulum 40 to 70 microns in diameter.

SIZE RANGE: Equatorial diameter 450 to 840 microns.

DISTRIBUTION: Neocomian. Common near the base of the Ellerslie Member.

This species was first described from the Wealden of the Netherlands by Dijkstra (1951).

REMARKS: The thickness of the muri is very much dependent upon the amount of abrasion and oxidative maceration. The muri are thin and high on better preserved specimens, but thick and low on badly preserved spores.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 21, figs. 4, 5. Depth 3188 to 3197 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 21, fig. 4. Slide No. Mega. 95; co-ord. 11.5/64.

Pl. 21, fig. 5. Slide No. Mega. 95; co-ord. 14.5/67.5.

Genus Verrutriteles (Van der Hammen, 1954) Potonie, 1956

1949 Triletes compositipunctatus Dijkstra, Meded. Geol. Stichting, Nw. Ser., No. 3, p. 22, pl. 1, fig. 8.

1954 Verrutriteles Van der Hammen, Bot. Geol. 2, Nr. 1, p. 14, Bogota.

1956 Verrutriteles compositipunctatus (Van der Hammen) Potonie, Beih. Geol. Jb., vol. 23, p. 28, pl. 3, figs. 24, 25, (type species).

DIAGNOSIS: Trilete megaspores; equatorial as well as meridional outline approximately circular to sub-triangular; trilete rays not reaching the equator; arcuate ridges indistinct; exine ornamented with hemispherical warts to low coni of various sizes which may sometimes be fused at the bases with one another; contact area may be smooth (V. carbunculus) or may be ornamented with small verrucae to coni (V. dubius), or may not be differentiated at all, and covered with the same ornamentation as the rest of the spore surface (V. compositipunctatus).

Verrutriteles cf. V. compositipunctatus (Van der Hammen) Potonie, 1956

Plate 21, figure 6

1949 Triletes compositipunctatus Dijkstra, Meded. Geol. Stichting, Nw. Ser. No. 3, p. 22, pl. 1, fig. 8.

1954 Verrutriteles Van der Hammen, Bot. Geol. 2, Nr. 1, p. 14, Bogota.

- 1956 Verrutriteles compositipunctatus (Van der Hammen) Potonie, Beih. Geol. Jb., vol. 23, p. 28, pl. 3, figs. 24, 25, (type species).

DESCRIPTION: Trilete megaspore; equatorial outline sub-triangular; proximal surface slightly convex, the distal surface strongly convex; trilete cracks present on very conspicuous triradiate ridges which are about 25 microns high and about 35 microns broad, extending up to 4/5 of the spore radius; arcuate ridges not seen; exine ornamented with irregular warts 5 to 25 microns in diameter and 5 to 15 microns high; spore wall very thick.

SIZE RANGE: Equatorial diameter 330 microns.

DISTRIBUTION: Barremian? to Senonian. Rare. In central Alberta this species was recorded from the Wabiskaw Member. It was first described from the Senonian of the Netherlands by Dijkstra (1949).

REMARKS: The holotype of Verrutriteles compositipunctatus has a more rounded outline with fewer, more rounded, and larger verrucae on the surface than the Alberta specimens.

Verrutriteles Van der Hammen, 1954 was a nomen nudum until Potonie (1956) made it legitimate by designating a type species and publishing a generic diagnosis with illustrations.

LOCALITY OF FIGURED SPECIMEN: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Pl. 21, fig. 6. Depth 3572 to 3582 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 21, fig. 6. Slide No. Mega. 119; co-ord. 11/37.5.

Genus Erlansonisporites Potonie, 1956

- 1932 Selaginellites erlansonii Miner, Jour. Washington Acad. Sci. 22, pp. 500, 501, fig. 1.

1956 Erlansonisporites erlansonii (Miner) Potonie, Beih. Geol. Jahr., vol. 23, pp. 46, 47, pl. 5, fig. 53, (type species).

DIAGNOSIS: Trilete megaspores; outline circular; the trilete mark may be completely covered by strong reticulation and is partially or not at all visible; the muri on the reticulum transformed into thin and high membraneous lamellae which are equally well developed all over the exine; especially at the periphery.

Erlansonisporites reticulatus n. sp.

Plate 22, figures 1, 2

DESCRIPTION: Trilete megaspore; outline of the spore completely circular; trilete mark may be entirely covered by strong reticulation and partially or not at all visible; when the high membraneous lamellae on the muri of the reticulum are destroyed by oxidative maceration, a faint trilete crack about 1/3 the length of the spore radius can be seen; arcuate lamellae absent; contact faces not distinguishable; a coarse network of muri 4 to 7 microns wide, forming circular to elongate lumina 34 to 60 microns in diameter, is present all over the spore surface; the muri of the reticulum are transformed into thin and membraneous lamellae about 60 microns high which are equally well developed all over the exine, but better preserved around the periphery due to flattening of the spherical body.

SIZE RANGE: Equatorial diameter of body (including the lamellae)
580 to 660 microns. Holotype 580 microns.

Equatorial diameter of body (excluding the lamellae)
480 to 550 microns. Holotype 480 microns.

Length of the lamellae about 60 microns.

DISTRIBUTION: Barremian? to Middle Albian. Common. In central Alberta

this species was recorded from the Ellerslie Member and the Grand Rapids Formation.

REMARKS: This species can be distinguished from Erlansonisporites erlansonii (Miner, 1932) Potonie, 1956, by its smaller size and larger number of lumina with smaller diameter.

TYPE LOCALITY: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Holotype: Pl. 22, fig. 1. Depth 2460 to 2469 feet; Grand Rapids Formation.
Pl. 22, fig. 2. Depth 3156 to 3165 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 22, fig. 1. Slide No. Mega. 28; co-ord. 11.5/40.
Pl. 22, fig. 2. Slide No. Mega. 91; co-ord. 11/37.

Erlansonisporites sparassis? (Murray) Potonie, 1956

Plate 22, figures 3-9

- 1939 Triletes sparassis Murray, Geol. Mag., vol. 76, p. 480, text - figs. 3, 4.
1956 Erlansonisporites sparassis (Murray) Potonie, Beih. Geol. Jahrb., vol. 23, p. 47.
1961 Triletes sparassis Murray in Harris, British Mus. Nat. Hist., Part I., p. 57, text - figs. 18A-D.

DESCRIPTION: Trilete megaspore; body of the spore nearly spherical; tri-radiate ridges about $\frac{2}{3}$ as long as the spore radius; arcuate lamellae absent; contact faces not distinguishable; a coarse network of ridges with wide and irregular meshes is present all over the spore surface; the high membraneous lamellae initially present on the network of ridges have been destroyed due to slightly excessive oxidative maceration; however, illustrations on plate 22, figures 3 and 4 have the membraneous lamellae partially preserved which indicate that they were originally 40 to 60 microns high; as indicated by Harris (1961, pp. 57, 58, 59), this species is very variable partly because the outer membraneous lamellae are highly susceptible to oxidative maceration, and partly because of immaturity of some of the specimens.

SIZE RANGE: Equatorial diameter (maximum) 390 (434) 461 microns.

DISTRIBUTION: Middle Jurassic to Aptian? Abundant. In central Alberta this species is restricted to the Ellerslie Member. Most of the specimens were recorded from a single sample taken from the middle of the Ellerslie Member.

REMARKS: It is not possible to identify this species with any degree of certainty because no complete specimens with membraneous lamellae were preserved. Some specimens with lamellae covered by sediment were initially seen. However, the application of further oxidative maceration, to make the spore more translucent, and to expose the trilete mark, destroyed the membraneous lamellae.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 22, fig. 3. Depth 3001 to 3010 feet; Ellerslie Member.

Pl. 22, figs. 4-9. Depth 3093 to 3102 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 22, fig. 3. Slide No. Mega. 60; co-ord. 9.5/35.

Pl. 22, fig. 4. Slide No. Mega. 74; co-ord. 11/36.

Pl. 22, fig. 5. Slide No. Mega. 73; co-ord. 12/37.

Pl. 22, fig. 6. Slide No. Mega. 79; co-ord. 9/36.

Pl. 22, fig. 7. Slide No. Mega. 79; co-ord. 12/37.

Pl. 22, fig. 8. Slide No. Mega. 79; co-ord. 11/34.

Pl. 22, fig. 9. Slide No. Mega. 73; co-ord. 10/38.

Erlansonisporites globosus n. sp.

Plate 23, figures 1, 2

DESCRIPTION: Trilete megaspore; outline of the spore completely circular; trilete mark can be seen clearly because the membraneous lamellae on the muri are not very high; trilete crack extending up to 3/4 of the spore radius or nearly reaching the equator; arcuate lamellae absent; contact faces not distinguishable; a coarse network of muri about 5 microns wide, forming circular to angular lumina about 24

microns in diameter, is present all over the spore surface; the muri become thin and membraneous as they rise above the surface of the spore and are about 20 to 30 microns high, it is believed that they originally rose higher than this, but that the thinner and membraneous portion at the top was destroyed by excessive oxidative maceration; the wall of the spore is characteristically thickened; average wall thickness is about 20 microns.

SIZE RANGE: Equatorial diameter 320 to 375 microns. Holotype 372 microns.

DISTRIBUTION: Barremian? to Aptian. Rare. In central Alberta this species was recorded from the Ellerslie Member only.

REMARKS: This species can be distinguished from Erlansonisporites reticulatus n. sp. by its smaller size, thicker wall, much longer laesurae which nearly reach the equator, and the shorter membraneous lamellae on the muri.

TYPE LOCALITY: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Holotype: Pl. 23, fig. 1. Depth 3001 to 3010 feet; Ellerslie Member.

Pl. 23, fig. 2. Depth 3156 to 3165 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 23, fig. 1. Slide No. Mega. 63; co-ord. 12/40.2.

Pl. 23, fig. 2. Slide No. Mega. 92; co-ord. 14/38.5.

Erlansonisporites sp.

Plate 23, figure 3

DESCRIPTION: Equatorial outline of the megaspore circular; trilete mark completely covered by thick reticulation and not visible; a coarse network of muri 3 to 4 microns wide outlining circular to four-sided lumina about 10 microns in diameter are present all over the spore surface; the muri are transformed into thin, membraneous

lamellae about 20 microns high which are equally well developed all over the exine, but better preserved around the periphery due to flattening of the spherical body.

SIZE RANGE: Equatorial diameter of body (including the lamellae) 240 microns.

Equatorial diameter of body (excluding the lamellae) 200 microns.

Length of lamellae about 20 microns.

Thickness of the spore wall about 10 microns.

DISTRIBUTION: Barremian? Rare. In central Alberta this species was recorded from the Deville Member only.

REMARKS: Although at the first sight this species looks similar to Tasmanites, the body is distinctly reticulate when examined under oil immersion, and the muri can be seen arising from the body on the margin. However, the surface of the body is strongly convex and only a few lumina come into focus at one time.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 23, fig. 3. Depth 3222 to 3231 feet; Deville Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 23, fig. 3. Slide No. Mega. 106; co-ord. 11/36.5.

Genus Maexisporites Potonie, 1956

1951 Triletes soldanellus Dijkstra, Netherlands, Meded. Geol. Stichting, new ser., no. 5, p. 10, pl. 2, fig. 17.

1956 Maexisporites soldanellus (Dijkstra) Potonie, Beih. Geol. Jahrb., vol. 23, pp. 25, 26, pl. 2, figs. 17, 18, 19, (type species).

DIAGNOSIS: Trilete megaspores; equatorial contour sub-triangular with convex sides; apices more or less rounded, but sometimes acute; triradiate ridges extending up to 3/4 of the spore radius and in some species even up to the margin of the spore; contact area may or may not be perceptible; the proximal side may be raised into a

pyramid-shaped structure or may be sunken, with the triradiate ridges on the trilete mark; exine almost smooth, very finely granulate to indistinctly granulate, granules 2 microns in diameter.

Maexisporites soldanellus (Dijkstra) Potonie, 1956

Plate 23, figure 4

- 1951 Triletes soldanellus Dijkstra, Netherlands, Meded. Geol. Stichting, new ser., no. 5, p. 10, pl. 2, fig. 17.
 1956 Maexisporites soldanellus (Dijkstra) Potonie, Beih. Geol. Jahrb., vol. 23, pp. 25, 26, pl. 2, figs. 17, 18, 19.

DESCRIPTION: Trilete megaspore; equatorial outline sub-triangular with convex sides and rounded apices; triradiate ridges on the trilete mark reach close to the margin of the spore; contact area not visible; the proximal side is raised into a pyramid-shaped structure whose faces are bound by the triradiate ridges, under this raised pyramid-shaped structure air is trapped in the illustrated specimen; exine finely granulate with granules of 2 microns or more in diameter; dark brown in colour.

SIZE RANGE: Total equatorial diameter 384 microns.

Height of the triradiate ridges 15 microns.

Width of the triradiate ridges 30 to 40 microns.

Thickness of the spore coat 40 microns.

DISTRIBUTION: Berriasian to Aptian. Rare. In central Alberta a single specimen of this species was found in the Ellerslie Member. It was first described from the English Wealden (Berriasian to Aptian) by Dijkstra (1951).

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).
 Pl. 23, fig. 4. Depth 3093 to 3102 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 23, fig. 4.

Slide No. Mega. 76;

co-ord. 11/35.5.

Maexisporites obolus (Dijkstra) Potonie, 1956

Plate 23, figures 5, 6

1951 Triletes obolus Dijkstra, Netherlands, Meded. Geol. Stichting, new ser., no. 5, p. 10, pl. 2, fig. 18.

1956 Maexisporites obolus (Dijkstra) Potonie, Beih. Geol. Jahrb., vol. 23, p. 26.

DESCRIPTION: Trilete megaspore; equatorial outline sub-triangular with convex sides and rounded apices; triradiate ridges on the trilete mark extend up to the margin of the spore; proximal face is sunken on which the triradiate ridges rise to a considerable height; exine finely granulate; granules about 2 microns in diameter; dark brown in colour.

SIZE RANGE: Total equatorial diameter 224 to 290 microns.

Height of triradiate ridges 20 microns.

Width of triradiate ridges 20 microns.

Thickness of spore coat 30 microns.

DISTRIBUTION: Hauterivian to Barremian. Common. In central Alberta this species was recorded from the Deville Member and the base of the Ellerslie Member. This species was first described from the Hauterivian Stage of the English Wealden by Dijkstra (1951).

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 23, fig. 5. Depth 3222 to 3231 feet;

Deville Member.

Pl. 23, fig. 6. Depth 3093 to 3102 feet;

Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 23, fig. 5. Slide No. Mega. 110;

co-ord. 12/34.5.

Pl. 23, fig. 6. Slide No. Mega. 77;

co-ord. 11/35.

Genus Thomsonia Madler, 1954

- 1954 Thomsonia reticulata Madler, Geol. Jb. 70, p. 150, pl. 5, fig. 15, (type species).

DIAGNOSIS: Trilete megaspores; body of spore almost spherical; outer margin of the arcuate lamellae triangular with convex sides and with well developed auricles at the apices; the triradiate lamellae are well developed, flap-like and high with usually waved margin; long and slender, forked or simple appendages arise close to or attached with the triradiate lamellae; contact area reaches up to or close to the equator; exine on the distal surface is mostly reticulate, but may be verrucate or covered with coni.

Thomsonia phyllicus (Murray) Potonie, 1956

Plate 23, figure 7

- 1939 Triletes phyllicus Murray, Geological Magazine, vol. 76, p. 482, text - figs. 7, 8.
 1956 Thomsonia phyllicus (Murray) Potonie, Beih. Geol. Jahrb., vol. 23, p. 72.

DESCRIPTION: Trilete megaspore; body spherical, triradiate lamellae leaf-like, one on either side of the triradiate scar, very high; distal surface covered with ridges forming an irregular mesh, the ridges are prolonged to form short, simple spines at the intersections of the mesh; very long, simple or forked, slender appendages arise near the triradiate lamellae.

SIZE RANGE: Diameter of the body 200 microns.

Height of the triradiate lamellae 220 microns.

Length of appendages 150 microns.

Diameter of mesh formed by ridges 1 to 2 microns.

Height of the spines 15 microns.

DISTRIBUTION: Middle Jurassic to Lower Cretaceous. Very rare. In central Alberta only two specimens were found. One was recorded from the Ellerslie Member, and the other near the top of the Grand Rapids Formation.

REMARKS: Thomsonia is distinguished from Minerisporites by the presence of hairy appendages in the apical (proximal) region of the former.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 23, fig. 7. Depth 3093 to 3102 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 23, fig. 7. Slide No. Mega. 78; co-ord. 8.8/35.2.

Genus Minerisporites Potonie, 1956

1935 Selaginellites mirabilis Miner, Amer. Midl. Nat. 16, p. 618, pl. 23, fig. 1.

1956 Minerisporites mirabilis Potonie, Beih. Geol. Jahrb., vol. 23, p. 67, pl. 9, figs. 87, 88, (type species).

DIAGNOSIS: Trilete megaspores; equatorial outline of the central body sub-triangular to almost circular; meridional outline of the central body semi-circular to circular; the thin equatorial zona is widest at the apices onto which the triradiate lamellae (tectae) on the trilete laesurae extend, this results in making the equatorial outline of the zona more triangular; triradiate lamellae extend up to the outer margin of zona and are strongly raised into a flap-like structure which are considerably higher than wide; the exine is thin, reticulate with vesicular lumina and curved muri.

Minerisporites macroreticulatus n. sp.

Plate 23, figures 8-11; plate 24, figures 1, 2

DESCRIPTION: Trilete megaspore; equatorial outline of the central body

triangular to nearly circular; thin and finely granular equatorial zona is widest at the apices onto which the triradiate lamellae (tectae) on the trilete laesurae extend, this results in making equatorial outline of the zona more triangular; triradiate lamellae extend up to the outer edge of the zona and are very high; exine thin with very distinct and wide reticulum; muri thin with hair-like or membraneous outgrowths.

SIZE RANGE: Total equatorial diameter (including zona) 385 (461) 570 microns.
Holotype 500 microns.

Width of zona at apices 65 (93) 120 microns. Holotype 75 microns.

Width of zona at sides 30 (40) 50 microns. Holotype 35 microns.

Width of triradiate lamellae (tectae) about 7 microns.

Height of the triradiate lamellae about 120 microns.

Width of lumina 40 microns (average).

Width of muri 1 micron.

DISTRIBUTION: Middle Albian. Abundant. In central Alberta this species has been recorded only from the uppermost continental portion of the Grand Rapids Formation.

REMARKS: This species differs from Minerisporites marginatus (Dijkstra, 1951) Potonie, 1956 in having a larger size, very distinct and wide reticulum, and hair-like or membraneous outgrowths on the muri.

The genus Minerisporites can be distinguished from Henrisporites by the clearly defined reticulate structure of the exine. Henrisporites has an exine ornamented with small conical processes or spines.

Miner (1932) should not have placed his specimens in the genus Selaginellites. This genus should, if we follow Halle (1907) be restricted to fossil shoots which show

convincing evidence of closer agreement with Selaginella than any other genus.

TYPE LOCALITY: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Holotype: Pl. 23, fig. 8 .	Depth 2442 to 2451 feet;	Grand Rapids Formation.
Pl. 23, fig. 9 .	Depth 2442 to 2451 feet;	Grand Rapids Formation.
Pl. 23, figs. 10, 11.	Depth 2478 to 2487 feet;	Grand Rapids Formation.
Pl. 24, figs. 1, 2.	Depth 2478 to 2487 feet;	Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 23, fig. 8 .	Slide No. Mega. 4;	co-ord. 11.4/37.8.
Pl. 23, fig. 9 .	Slide No. Mega. 3;	co-ord. 7.2/49.
Pl. 23, fig. 10.	Slide No. Mega. 32;	co-ord. 17.9/53.1.
Pl. 23, fig. 11.	Slide No. Mega. 32;	co-ord. 8.2/60.
Pl. 24, fig. 1.	Slide No. Mega. 32;	co-ord. 19.5/51.
Pl. 24, fig. 2 .	Slide No. Mega. 33;	co-ord. 13.8/45.

Minerisporites marginatus (Dijkstra) Potonie, 1956

Plate 24, figures 3-7

- 1951 Triletes marginatus Dijkstra, Netherlands, Meded. Geol. Stichting, new ser., no. 5, p. 13, pl. 3, fig. 11.
- 1955 Baldurnisporites marginatus (Dijkstra) Delcourt and Sprumont, Mem. Soc. Belge. Geol., new ser., no. 5, p. 73, pl. 4, fig. 5.
- 1956 Minerisporites marginatus (Dijkstra) Potonie, Beih. Geol. Jahrb., vol. 23, p. 68.

DESCRIPTION: Trilete megaspore; equatorial outline of the central body sub-triangular to nearly circular; meridional outline is almost circular; the thin, finely granular equatorial zona is widest at the apices onto which the triradiate lamellae (tectae) on the trilete laesurae extend; the equatorial outline of the zona is triangular; the triradiate lamellae extend up to the outer edge of the zona; exine thin, faintly and irregularly reticulate, with rather narrow lumina and arcuate narrow muri.

SIZE RANGE: Total equatorial diameter (including zona) 282 (301) 350 microns.

Width of zona at apices about 50 microns.

Width of zona on sides about 20 microns.

Width of triradiate lamellae (tectae) about 5 microns.

Height of triradiate lamellae about 180 microns.

Width of lumina 10 to 20 microns.

Width of muri 1.5 microns.

DISTRIBUTION: Lower Cretaceous. Abundant. In central Alberta this species occurs throughout the Mannville Group. It has been previously recorded from the Lower Cretaceous (Wealden) of the Netherlands (Dijkstra, 1951), Belgium (Delcourt and Sprumont, 1955) and South Australia (Cookson and Dettmann, 1958).

AFFINITY: The probable affinity of *Minerisporites* is with the family Selaginellaceae.

REMARKS: Recently, Delcourt et al. (1963, p. 289) have agreed to the removal of the megaspore species *Minerisporites marginatus* from the genus *Baldurnisporites*, which has been restricted to microspores only.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 24, figs. 3, 4.	Depth 3084 to 3093 feet;	Ellerslie Member.
Pl. 24, fig. 6.	Depth 3093 to 3102 feet;	Ellerslie Member.
Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).		
Pl. 24, figs. 5, 7.	Depth 1781 to 1791 feet;	Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 24, fig. 3.	Slide No. Mega. 71;	co-ord. 10/36.5.
Pl. 24, fig. 4.	Slide No. Mega. 71;	co-ord. 10/37.
Pl. 24, fig. 5.	Slide No. Mega. 19;	co-ord. 7/45.
Pl. 24, fig. 6.	Slide No. Mega. 78;	co-ord. 9.8/48.2.
Pl. 24, fig. 7.	Slide No. Mega. 18;	co-ord. 7/46.

Minerisporites venustus n. sp.

Plate 24, figures 8, 9; plate 25, figures 1-6

DESCRIPTION: Trilete megaspore; equatorial outline of the central body always

circular; arcuate lamellae closer to the proximal side, not positioned at the equator but in the proximal hemisphere; arcuate lamellae widest at the apices onto which the triradiate lamellae on the trilete laesurae extend; the triradiate lamellae extend up to the outer edge of the arcuate lamellae and are not high; arcuate lamellae thin; exine thin; surface granular, with some indications of a small-meshed reticulation having very low, convolute and narrow muri, most specimens, however, do not show any sign of reticulation, which may be due to the destruction of the external ornamentation by abrasion or oxidative maceration; colour pale yellow, translucent.

SIZE RANGE: Total equatorial diameter (including arcuate lamellae)
320 (374.6) 410 microns. Holotype 380 microns.

Width of arcuate lamellae at apices 20 (33.3) 50 microns.

Width of arcuate lamellae at sides 20 to 60 microns.

Width of triradiate lamellae (tectae) about 10 microns.

Height of the triradiate lamellae about 50 microns.

Width of lumina about 20 microns.

Width of muri 0.2 microns.

DISTRIBUTION: Middle Albian. Abundant. In central Alberta this species has been recorded only from the Clearwater Formation and the uppermost continental portion of the Grand Rapids Formation.

REMARKS: This species differs from other species of Minerisporites in having the arcuate lamellae in the proximal hemisphere rather than on the equator, a small-meshed reticulum with very low, convolute and narrow muri, which may be entirely absent, thin and fragile wall, and round outline. There is some doubt as to whether a form with arcuate lamellae in the proximal hemisphere rather than an equatorial

zona should have been placed in the genus Minerisporites. However, the lamellae are not far removed from the equator and the body is faintly reticulate, hence there appears to be no need to erect a new genus.

TYPE LOCALITY: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Holotype: Pl. 24, fig. 8. Depth 2442 to 2451 feet; Grand Rapids Formation.
 Pl. 24, fig. 9. Depth 2442 to 2451 feet; Grand Rapids Formation.
 Pl. 25, figs. 1, 2. Depth 2442 to 2451 feet; Grand Rapids Formation.

Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 25, fig. 3. Depth 1891 to 1901 feet; Grand Rapids Formation.
 Pl. 25, figs. 4, 5. Depth 2045 to 2055 feet; Clearwater Formation,
 Shale Member.

Pl. 25, fig. 6. Depth 1781 to 1791 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 24, fig. 8. Slide No. Mega. 3; co-ord. 12/36.8.
 Pl. 24, fig. 9. Slide No. Mega. 17; co-ord. 10.6/44.
 Pl. 25, fig. 1. Slide No. Mega. 6; co-ord. 14/35.
 Pl. 25, fig. 2. Slide No. Mega. 7; co-ord. 13.2/50.8.
 Pl. 25, fig. 3. Slide No. Mega. 42; co-ord. 10/44.8.
 Pl. 25, fig. 4. Slide No. Mega. 50; co-ord. 12.5/41.
 Pl. 25, fig. 5. Slide No. Mega. 50; co-ord. 11/40.5.
 Pl. 25, fig. 6. Slide No. Mega. 21; co-ord. 9/43.

Genus Dijkstrasporites Potonie, 1956

- 1951 Triletes helios Dijkstra, Netherlands, Meded. Geol. Stichting, new ser., no. 5, p. 11, pl. 3, fig. 17.
- 1956 Dijkstrasporites helios (Dijkstra) Potonie, Beih. Geol. Jahrb., vol. 23, p. 74, pl. 10, figs. 99, 100, (type species).

DIAGNOSIS: Trilete megaspores; zonate to coronate; equatorial outline of the central body circular to sub-triangular, but with the thin equatorial zona, the outline of the spore is always circular; equatorial zona is transparent, membraneous and broad and may contain a great number of thin rays; the margin of the zona may be continuous or radially ruptured (coronate); the triradiate lamellae extend onto the zona, and are thick, flap-like structures, borne on the trilete mark; these lamellae may also have

similarly ruptured margins or may bear free hair-like appendages (capilli); the exine is reticulate or granular to verrucose.

Dijkstraisporites helios (Dijkstra) Potonie, 1956

Plate 25, figures 7-10

- 1951 Triletes helios Dijkstra, Netherlands, Meded. Geol. Stichting, new ser., no. 5, p. 11, pl. 3, fig. 17.
 1956 Dijkstraisporites helios (Dijkstra) Potonie, Beih. Geol. Jahrb., vol. 23, p. 74, pl. 10, figs. 99, 100.

DESCRIPTION: Trilete coronate megaspore; the equatorial outline of the central body as well as the equatorial corona is circular; equatorial corona is transparent, membranous and broad with a great number of thin rays projecting into it from the central body; these rays anastomose over 2/3 of their length and then the free ends enter the radially ruptured branches of the corona; the margin of the corona is radially ruptured (coronate), and the ripped ends are often fan-shaped or bilobed; the triradiate lamellae (tectae) borne on the trilete mark are thick, flap-like structures which extend to the margin of the corona, and have a radially ruptured margin as in the case of corona; both the proximal and distal faces are convex, with a reticulate pattern enclosing lumina of somewhat uniform size.

SIZE RANGE: Total equatorial diameter (including corona)
 450 (540) 615 microns.

Width of corona 128 (152) 192 microns.

Width of triradiate lamellae (tectae) about 30 microns.

Height of triradiate lamellae (tectae) 50 to 60 microns.

Width of lumina about 19 microns.

Width of muri 2 microns.

DISTRIBUTION: Barremian to Aptian. Abundant. In central Alberta this species has so far been recorded from the Ellerslie and Deville Members only. It was first described from the Barremian-Aptian horizon in England by Dijkstra (1951). It is an important stratigraphic marker.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 25, figs. 7, 8, 10. Depth 3213 to 3222 feet; Deville Member.

Pl. 25, fig. 9. Depth 3222 to 3231 feet; Deville Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 25, fig. 7. Slide No. Mega. 98; co-ord. 12.2/37.

Pl. 25, fig. 8. Slide No. Mega. 101; co-ord. 10.5/35.8.

Pl. 25, fig. 9. Slide No. Mega. 107; co-ord. 13/36.

Pl. 25, fig. 10. Slide No. Mega. 96; co-ord. 11/38.

Dijkstraisporites triangulatus n. sp.

Plate 26, figure 1

DESCRIPTION: Trilete coronate megaspore; equatorial outline of the central body triangular with convex sides, but the equatorial corona surrounding it, gives the spore a more or less circular outline; corona translucent, membranous, thinning out towards the margin, not very wide when compared with the size of the body; a large number of 10 microns thick rays project into the corona from the central body, these rays run over $\frac{2}{3}$ of their length separately embedded in the membranous corona which is continuous, but at their extremities they enter the radially ruptured lobes of corona; the triradiate lamellae borne on the trilete mark are thick, high and flap-like structures which extend to the margin of the corona, and have a radially ruptured margin as in the case of corona; both the proximal as well as distal surfaces of the central body are convex, with coarsely reticulate pattern enclosing lumina of variable size.

SIZE RANGE: Total equatorial diameter (including corona) about 737 microns.
Holotype 737.2 microns.

Width of corona about 141 microns.

Width of triradiate lamellae about 50 microns.

Height of triradiate lamellae about 192 microns.

Width of lumina 20 to 45 microns.

Width of muri 4 microns.

DISTRIBUTION: Middle Albian. Rare. In central Alberta this species was recorded from the lower portion of the Wabiskaw Member.

REMARKS: This species is distinguished from D. helios by its larger size, triangular central body, narrower corona with thick separate rays supporting it. The triradiate lamellae are much higher and the reticulate pattern on the central body is coarser in D. triangulatus n. sp. than in D. helios (Dijkstra, 1951) Potonie, 1956.

TYPE LOCALITY: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Holotype: Pl. 26, fig. 1. Depth 2923 to 2932 feet; Wabiskaw Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 26, fig. 1. Slide No. Mega. 56; co-ord. 10.5/39.

Genus Arcellites (Miner, 1935) Ellis and Tschudy, in press

1935 Arcellites disciformis Miner, Amer. Midl. Nat., vol. 16, p. 600, pl. 20, figs. 61, 64 - 66, (type species).

1950 Arcellites crillensis Schemel, Amer. Journ. Bot., vol. 37, pp. 751-753, figs. 16 - 19.

1955 Pyrobolospora Hughes, Geol. Mag., vol. 92, p. 204.

In press Arcellites disciformis (Miner) Ellis and Tschudy, Morphology and distribution of the Cretaceous megaspore genus Arcellites Miner, 1935 (Pyrobolospora Hughes, 1955), Micropaleo., January, 1964.

DIAGNOSIS: Trilete spores in the megaspore size range (150 microns and larger); spore-body spherical (and not axially elongated) with a prominent neck composed

of (usually) six segments; the body of the spore is uniformly covered by sculptine detail which may vary in different species from small granules to appendages 300 microns long; endexine is much thinner and darker coloured than the ectexine; small triradiate tetrad scar is present apically beneath the neck and may only be seen by dissection.

Arcellites rugosus n. sp.

Plate 26, figures 2-4

DESCRIPTION: Trilete megaspore; spore body approximately spherical, with a neck which is nearly always longer than the spore body diameter, and composed of six leaf-like segments fused by their margins into six ridges extending upwards, and the centre part of each segment is folded inwards; trilete mark is probably present apically beneath the neck; the thickness of the leaf-like segments decreases from the base upwards; spore body smooth, covered with broad and high, irregularly arranged ridges with indications of a reticulate arrangement; the ridge pattern is controlled by a pattern of thickening in the wall; the development of the ridges may be incipient and only faintly indicated, or may be well marked as on the holotype.

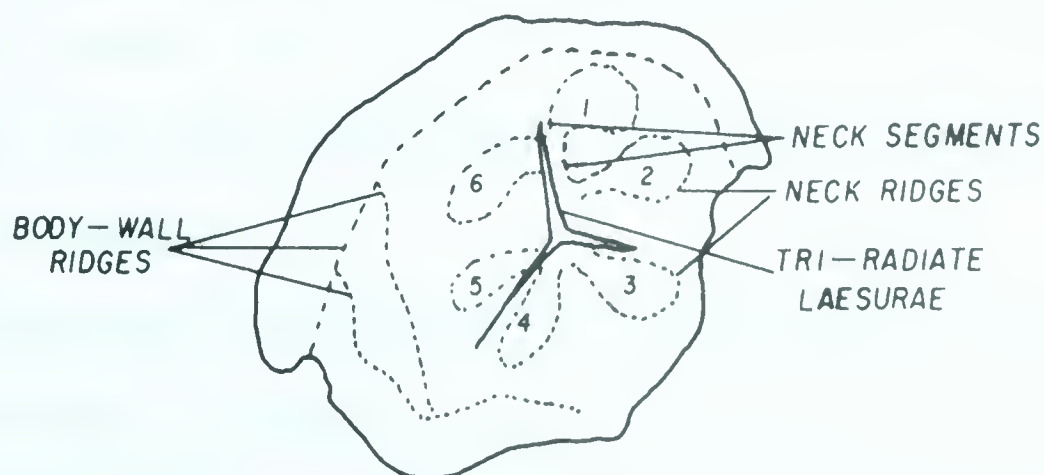


Figure 13. Arcellites vectis (Hughes) Ellis and Tschudy. A transverse section at the spore-apex (after Hughes, 1955) showing the 6 neck ridges and the 6 leaf-like neck segments.

SIZE RANGE: Total length (including neck) 570 (625) 670 microns.

Holotype 670 microns.

Diameter of body 270 (295) 310 microns.

Holotype 310 microns.

Length of neck 300 (330) 370 microns.

Holotype 370 microns.

Width of ridges on body about 30 microns.

Height of ridges on body 20 to 40 microns.

DISTRIBUTION: Barremian? to Aptian. Common. In central Alberta this species makes its first appearance in the Deville Member becoming common in the Ellerslie Member.

AFFINITY: The occurrence of the various species of the genus Arcellites in the deposits of lacustrine, fluvial or paralic origin, the general morphological pattern of a terminal trilete mark under the neck appendages, and the numerous hollow appendages or bladders which add buoyancy to the spore body suggest an aquatic habit. This genus has a possible affinity with the water ferns of the orders Salviniiales or Marsileales.

REMARKS: Miner (1935), described Arcellites disciformis from the Upper Cretaceous Coals of Greenland. As the neck segments on his specimens were not preserved he misunderstood the morphology and described them in following words: "Body small, circular, with a few to several short tube-like appendages, surface pitted, pits minute." The "tube-like appendages" induced him to think that they were perhaps fresh-water rhizopods.

Schemel (1950), described Arcellites crillensis from the Dakota Formation of Iowa, United States. Although, his specimens were not very well preserved, the neck segments were present in this case. Schemel found A. crillensis to be identical with

A. disciformis in ornamentation and tube-like appendages. The only difference between the two, according to him, was that A. crillensis possessed three "wing-like extensions" (neck segments). But he observed that "Miner's illustrated specimens appear to be broken in such a manner that it is possible that they possessed the wing-like extensions also." The holotype of A. crillensis was not well preserved, and this can account for the fact that it had only three wing-like segments instead of six, and very small number of tube-like appendages. Hall (1962), described very well preserved specimens with six neck segments and a larger number of evenly spaced body appendages from the same horizon. He designated them as A. disciformis.

Hughes (1955), obviously unaware of these earlier descriptions based on incompletely preserved specimens, described well preserved specimens as the new genus Pyrobolospora from the Wealden of England. He described them accurately and in great detail for the first time. However, Hughes (pers. comm.) agrees that the genus Arcellites has priority, but at the same time he feels that since the genus Pyrobolospora is based on P. vectis which has coarsely reticulate ridges on its body, the genus Pyrobolospora should be restricted to the forms with murornate ornamentation. In the opinion of the writer, murornate ornamentation is only of specific value, and it would not serve any useful purpose to further sub-divide this distinctive group of megaspores with a spherical body and a neck composed of six segments.

Ellis and Tschudy (in press) have recently revised the genus Arcellites and designated Arcellites disciformis Miner, 1935 as the type species. They have synonymized A. crillensis Schemel, 1950 with A. disciformis and the genus Pyrobolospora Hughes, 1955 with the genus Arcellites Miner, 1935 and have rejected Pyrobolospora as a later synonym.

Arcellites rugosus can be distinguished from Arcellites nudus (Cookson and Dettmann) n. comb. by the absence of granular and pitted layers of ectexine. The presence of ridges on the spore body makes A. rugosus n. sp. look similar to Arcellites vectis (Hughes) Ellis and Tschudy. However, no appendages were seen attached to the ridges on the body. There is no sign of any scars left by detached appendages on any of the specimens. A. rugosus is on an average 207 microns longer than A. vectis. Whereas, the neck in A. vectis is always shorter than the diameter of the body, in A. rugosus n. sp. it is always longer than the diameter of the body.

TYPE LOCALITY: Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.).

Holotype: Pl. 26, figs. 2, 4. Depth 3632 to 3642 feet; Ellerslie Member.

Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 26, fig. 3. Depth 3249 to 3257 feet; Deville Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 26, figs. 2, 4. Slide No. Mega. 122; co-ord. 10.2/40.1.

Pl. 26, fig. 3. Slide No. Mega. 111; co-ord. 11.8/37.2.

Arcellites reticulatus (Cookson and Dettmann) n. comb.

Plate 26, figures 5-7

1958 Pyrobolospora reticulata Cookson and Dettmann, Micropaleo., vol. 4(1), pp. 40, 41, pl. 1, figures 2-6.

DESCRIPTION: Trilete megaspore; spore body nearly spherical with a reticulate surface; neck usually shorter than the diameter of the spore body, and composed of six leaf-like neck segments, adherent along their margins or free along their entire length; each neck segment folded inwards, and supported by a median rib which arises from the ectexine and runs forward to taper off behind the apex; outer margin of segments may be finely and transversely plicate; trilete mark situated

apically beneath the neck; spore coat about 15 microns thick, composed of three layers; innermost layer a brown homogeneous endexine, middle layer a dark brown inner ectexine, and the outermost layer a translucent light yellow-brown outer ectexine; reticulate surface developed mainly from the ectexine; the lumina are polygonal or hexagonal in outline; reticulum wide, the outer ectexine forms short funnel-shaped appendages at the angles of the reticulum, appendages very thin-walled distally and are, therefore, seldom found in a fully expanded condition.

SIZE RANGE: Total length (including neck) 577 (618.5) 718 microns.

Diameter of body 320.5 (342.8) 384.5 microns.

Length of neck 256 (275.4) 333.3 microns.

Width of reticulum 20 to 35 microns.

Width of muri 8 to 10 microns.

DISTRIBUTION: Albian. Abundant. In central Alberta this species has so far been found only in the uppermost continental beds of the Grand Rapids Formation. It was first described from the Lower Cretaceous (Albian) sediments of South Australia.

REMARKS: Arcellites reticulatus can be distinguished from other species of Arcellites by the clearly defined surface reticulum. As compared with the Australian specimens, the Canadian specimens appear to have a thicker wall.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 26, figs. 5-7. Depth 2442 to 2451 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 26, fig. 5. Slide No. Mega. 16; co-ord. 12/51.8.

Pl. 26, figs. 6, 7. Slide No. Mega. 12; co-ord. 11.8/39.5.

Arcellites incipiens n. sp.

Plate 27, figures 1, 2

DESCRIPTION: Trilete megaspore; spore body nearly spherical with a reticulate surface; the neck is about $1/3$ the diameter of the spore body and is probably composed of six neck segments which are folded inwards with a tetrad scar between them; the spore coat is very thin and fragile; spore body almost transparent; ectexine ornamented by a reticulate pattern; lumina polygonal or pentagonal in outline; reticulum very wide, ectexine forming elongated conical to rounded closed processes at the angles of the reticulum.

SIZE RANGE: Total length (including neck) 385 to 449 microns.

Holotype 385 microns.

Maximum diameter of body 269 to 350 microns.

Holotype 350 microns.

Length of neck 128 to 179 microns.

Holotype 128 microns.

Width of reticulum 40 to 50 microns.

Width of muri 7 to 10 microns.

Length of appendages 30 to 40 microns.

DISTRIBUTION: Barremian? and Aptian. Rare. In central Alberta this species has so far been recorded only from the Ellerslie Member.

REMARKS: This species can be distinguished from Arcellites reticulatus (Cookson and Dettmann) n. comb., by its comparatively much smaller neck compared with the body, overall smaller size, wider reticulum, thinner spore coat, and elongated conical to rounded closed processes at the junctions of the muri, instead of short funnel-shaped appendages.

Owing to the small number of specimens available none was sacrificed to determine the number of neck segments or the presence of a tetrad scar.

TYPE LOCALITY: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Holotype: Pl. 27, figs. 1, 2. Depth 3001 to 3010 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Holotype: Pl. 27, figs. 1, 2. Slide No. Mega. 62; co-ord. 9/35.

Arcellites nudus (Cookson and Dettmann) n. comb.

Plate 27, figures 3-8

1958 Pyrobolospora nuda Cookson and Dettmann, Micropaleo., vol. 4(1), pp. 41, 42, text-figs. 2a, c, d.

DESCRIPTION: Trilete megaspore; spore body nearly spherical and without appendages; neck nearly as long or slightly longer than the diameter of the spore body, composed of six leaf-like neck segments, probably enclosing a trilete mark and fused by their margins into six ridges running upwards; outer margins of the segments plicate; spore coat composed of four layers, yellow-brown in colour and from 15 to 20 microns thick; the innermost layer consists of a homogeneous endexine, in which a thin inner and a thicker outer endexine can be distinguished; the outer layers are composed of a double-layered ectexine, the inner layer is granular and the outer layer is coarsely pitted.

SIZE RANGE: Total length (including neck) 448.5 (517) 641 microns.

Diameter of body 270 to 372 microns.

Length of neck 270 to 320 microns.

DISTRIBUTION: Albian. Common. In central Alberta this species has so far been found only in the uppermost continental beds of the Grand Rapids Formation. It was first described from the Lower Cretaceous (Albian) sediments of South Australia.

REMARKS: Of the nine species of Arcellites that have so far been described from the Lower Cretaceous, A. nudus is the only one in which the exine is devoid of

appendages and is pitted. As compared with the Australian specimens, the Canadian specimens appear to have slightly shorter necks and a more coarsely pitted outer *ektexine*.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 27, figs. 3, 5, 6, 8. Depth 2478 to 2487 feet; Grand Rapids Formation.

Pl. 27, figs. 4, 7. Depth 2442 to 2451 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 27, figs. 3, 5, 6, 8. Slide No. Mega. 34; co-ord. 13/42.

Pl. 27, figs. 4, 7. Slide No. Mega. 10; co-ord. 11.5/37.5.

Arcellites disciformis (Miner) Ellis and Tschudy, in press

Plate 28, figures 1-5

1935 Arcellites disciformis Miner, Amer. Midl. Nat., vol. 16, p. 600, pl. 20, figs. 61, 64 - 66, (type species).

1950 Arcellites crillensis Schemel, Amer. Journ. Bot., vol. 37, pp. 751-753, figs. 16 - 19.

1955 Pyrobolospora Hughes, Geol. Mag., vol. 92, p. 204.

In press Arcellites disciformis (Miner) Ellis and Tschudy, Morphology and distribution of the Cretaceous megaspore genus Arcellites Miner, 1935 (Pyrobolospora Hughes, 1955), Micropaleo., January, 1964.

DESCRIPTION: Trilete megaspore; spore body approximately spherical, with a neck which is nearly always longer than the diameter of the spore body and composed of six leaf-like segments fused by their margins into six ridges running upwards, the centre part of each segment is folded inwards and they are usually twisted anti-clockwise; the thickness of the leaf-like neck segments decreases from the base upwards; spore body shows minutely pitted surface and bears about fifty translucent cylindrical and hollow appendages, a complete appendage when preserved bears a thin translucent disc on the end which may be a collapsed spherical bladder; spore coat is composed of three layers: a thick light coloured finely pitted outer *ektexine* with slight radial thickening,

a thin light coloured finely granular inner ectexine adhering to the endexine, these two layers of ectexine form the neck and appendages, the innermost third layer is composed of a thin dark coloured endexine.

SIZE RANGE: Total length (including neck and appendages)

487 (545) 679.5 microns.

Equatorial diameter of body 243.5 (256.5) 269 microns.

Length of neck 224 (271) 346 microns.

Length of appendages 64.1 (73.7) 102.5 microns.

Width of appendages 20 to 30 microns.

Diameter of the terminal disc on appendages 40 to 70 microns.

DISTRIBUTION: Barremian? to Cenomanian. Abundant. In central Alberta this species appears to be restricted to the Deville and the Ellerslie Members. It has been reported from the Upper Cretaceous of Greenland (Miner, 1935); Dakota Formation (Cenomanian) of Iowa (Schemel, 1950 and Hall, 1962) and from the Denver Basin, U.S.A. (Ellis and Tschudy, in press). "Pyrobolospora" hexapartita with which A. disciformis may be conspecific makes its first appearance in the section in the Upper Barremian Stage of the English Wealden (Hughes, 1955).

REMARKS: Arcellites disciformis (Miner) Ellis and Tschudy differs from "Pyrobolospora" hexapartita Hughes, 1955 in having an outer finely pitted and an inner granular layer of ectexine, visible under X 400 magnification. "P". hexapartita, as described by Hughes (1955), has a smooth spore body on which the outer ectexine layer has radial thickenings. Cookson and Dettmann (1958), who reported the same species from Australia, describe the surface of the spore body, neck segments and appendages as finely granular. Hall (1962), describes the outer ectexine layer on

A. disciformis as foveolate. He describes the effect of these foveae in a section of the wall in these words: "The foveae are all about the same radial extent, and seem to create a palisade-like outer layer". Perhaps this "palisade-like" outer layer has been described by Hughes as radial thickenings on the outer ectexine layer. If there is any difference between A. disciformis and "P. hexapartita", it is in the structure of the ectexine. The ectexine of the specimens so far assigned to "P. hexapartita" should be re-examined under high power to determine as to whether this difference really exists.

A. disciformis found in Canada is comparatively larger than "P. hexapartita", but the neck is not proportionately as long in comparison with the diameter of the spore body. Actually, in some cases the neck is of the same size or even slightly shorter than the diameter of the spore body. In "P. hexapartita" the neck is always much longer than the spore body diameter.

LOCALITY OF FIGURED SPECIMENS: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 28, figs. 1, 3, 4, 5.	Depth 3111 to 3120 feet;	Ellerslie Member.
Pl. 28, fig. 2.	Depth 3019 to 3028 feet;	Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 28, figs. 1, 4, 5.	Slide No. Mega. 85;	co-ord. 10/36.
Pl. 28, fig. 2.	Slide No. Mega. 65;	co-ord. 11/39.5.
Pl. 28, fig. 3.	Slide No. Mega. 85;	co-ord. 10/42.

Dictyothylakos sp.

Plate 29, figures 1-3

1954 Dictyothylakos pesslerae Horst, Z. Geologie 3, pp. 610-613.

DESCRIPTION: Mesh-like perispore covering the megaspore Thylakosporites retarius (Hughes, 1955) Potonie, 1956 which forms different layers of different mesh-sizes; width of the mesh strands ranges between 15 to 35 microns, and the strands

are often thick enough to be circular in cross section; the mesh is usually angular, with variable diameter which seldom exceeds 200 microns along its maximum width.

DISTRIBUTION: Neocomian to Middle Albian. Common. In central Alberta this species occurs throughout the Mannville Group.

REMARKS: All the mesh-like perispores cannot be included in this species. Specimens with distinctly larger mesh-diameter, which do not show the characteristic layers at different levels interwoven with each other do not belong to this species.

LOCALITY OF FIGURED SPECIMENS: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 29, figs. 1, 3. Depth 1791 to 1801 feet; Grand Rapids Formation.
Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 29, fig. 2. Depth 3222 to 3231 feet; Deville Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 29, figs. 1, 3. Slide No. Mega. 22; co-ord. 13/37.

Pl. 29, fig. 2. Slide No. Mega. 105; co-ord. 11/36.5.

Caytonia seed

Plate 29, figure 4

DESCRIPTION: Seed consisting of a rather thickly cutinized nucellus enclosed in a thinly cutinized integument; orthotropous in nature; nucellus composed of rows of elongated cells which become convoluted towards the base; integument is membranous with indistinct cell structure. Prof. Harris who has seen a photograph of this specimen considers it very similar to a Caytonia seed.

SIZE RANGE: Length 705 microns; breadth 435 microns.

LOCALITY OF FIGURED SPECIMEN: Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

Pl. 29, fig. 4. Depth 1846 to 1856 feet; Grand Rapids Formation.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 29, fig. 4. Slide No. Mega. 38; co-ord. 11/42.

Nucellus cuticle of Caytonia seed?

Plate 29, figures 5, 6

DESCRIPTION: The surface shows transverse wrinkles which are continuous around the body; longitudinal wrinkles are present laterally; body multicellular and hollow. Prof. Harris who has seen photographs of this specimen has informed the writer, that the isolated nucellus cuticle of a Caytonia seed often shows wrinkles just like this.

SIZE RANGE: Length 1100 microns; breadth 700 microns.

LOCALITY OF FIGURED SPECIMEN: Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.).

Pl. 29, figures 5, 6. Depth 2992 to 3001 feet; Ellerslie Member.

REPOSITORY: Res. Coun. Alberta Palynological Type Coll.

Pl. 29, figures 5, 6. Slide No. Mega. 59; co-ord. 11.2/67.

SELECTED
BIBLIOGRAPHY

- Allen, P. (1955): Age of the Wealden in northwestern Europe; *Geol. Mag.*, Vol. 92, No. 4, pp. 265-281.
- Arnold, C. A. (1947): An introduction to paleobotany; McGraw-Hill Book Co., Inc., New York, pp. 1-433.
- Badgley, P. C. (1952): Notes on the subsurface stratigraphy and oil and gas geology of the Lower Cretaceous Series in central Alberta; *Geol. Surv. of Canada*, Paper 52-11.
- Balme, B. E. (1957): Spore and pollen grains from the Mesozoic of Western Australia; *Commonwealth Sci. and Ind. Res. Organ., Coal Res. Section*, Chatswood, Ref. T.C. 25, pp. 1-50, pls. 1-11.
- Bell, W. A. (1956): Lower Cretaceous floras of western Canada; *Geol. Surv. Canada*, Memoir 285.
- Bolkhovitina, N. A. (1953): Spores and pollen characteristic of Cretaceous deposits of central regions of U.S.S.R.; *Acad. Sci. U.S.S.R., Inst. Geol. Sci.*, No. 145 (Geol. Series No. 61), pp. 1-183, pls. 1-16.
- _____ (1956): Atlas of spores and pollen from the Jurassic and Lower Cretaceous deposits of the Vilyui Basin; *Acad. Sci. U.S.S.R., Trans. Geol. Inst.*, No. 2, pp. 1-132, pls. 1-25.
- _____ (1959a): Spore and pollen complex from the Mesozoic sediments of the Vilyui Basin and their stratigraphic interpretation; *Acad. Sci. U.S.S.R., Trans. Geol. Inst.*, Vol. 24, pp. 1-184, pls. 1-8.
- _____ (1959b): The Morphology of the spores of the family Schizaeaceae and the history of the family in the geological past; *Acad. Sci. U.S.S.R., Palaeontological Journal*, No. 1, pp. 121-131.
- _____ (1961): Fossil and recent spores of the family Schizaeaceae; *Acad. Sci. U.S.S.R., Trans. Geol. Inst.*, Vol. 40, pp. 1-175, pls. 1-41.
- Bolkhovitina, N. A., et al. (1962): On the preparation for an interdepartmental conference on taxonomy and nomenclature of fossil spores and pollen; *Acad. Sci. U.S.S.R., Palaeontological Journal*, No. 3, pp. 130-135.

- Borden, R. L. (1956a): Mesozoic stratigraphy of the southern part of the Prairie Provinces, Canada; Jour. Alta. Soc. Petrol. Geol., Vol. 4, No. 3, pp. 59-63.
- _____ (1956b): Historical geology and tectonics of the southern part of the Prairie Provinces, Canada; Jour. Alta. Soc. Petrol. Geol., Vol. 4, No. 6, pp. 134-140.
- Brown, C. A. (1960): Palynological techniques; pp. 1-183, Louisiana State Univ., Baton Rouge, U.S.A.
- Carrigy, M. A. (1959): Geology of the McMurray Formation; Pt. 3, General geology of the McMurray area; Research Coun. Alberta, Memoir 1.
- Casey, R. C. (1961): The stratigraphical palaeontology of the Lower Greensand; Palaeontology, Volume 3, Pt. 4, pp. 487-621, pls. 77-84.
- Chaloner, W. G. (1959): Devonian megaspores from Arctic Canada; Palaeontology, Vol. 1, Pt. 4, pp. 321-332, pl. 55.
- Cobban, W. A., and Reeside, J. B. Jr. (1952): Correlation of the Cretaceous Formations of the western interior of the United States; Bull. Geol. Soc. Amer., Vol. 63, pp. 1011-1044.
- Cookson, I. C. (1947): Plant microfossils from the lignites of the Kerguelen Archipelago; B.A.N.Z. Antarct. Res. Expd. (1929-1931), Rept. 2(8), pp. 129-142.
- _____ (1950): Fossil pollen grains of the proteaceous type from Tertiary deposits in Australia; Aust. Jour. Sci. Res. B., 3, pp. 166-177.
- Cookson, I. C., and Dettmann, M. E. (1958a): Some trilete spores from the Upper Mesozoic deposits in the eastern Australian region; Royal Soc. Victoria, Melbourne, Vol. 70, Pt. 2, pp. 95-128, pls. 14-19.
- _____ (1958b): Cretaceous "megaspores" and a closely associated microspore from the Australian region; Micropaleontology, Vol. 4, No. 1, pp. 39-49, pls. 1-2.
- _____ (1959): On Schizosporis, a new form genus from Australian Cretaceous deposits; Micropaleontology, Vol. 5, No. 2, pp. 213-216, pl. 1.
- _____ (1961): Reappraisal of the Mesozoic microspore genus Aequitriradites; Palaeontology, Vol. 4, Pt. 3, pp. 425-427, pl. 1.

Cookson, I. C., and Eisenack, A. (1958): Microplankton from Australian and New Guinea Upper Mesozoic sediments; Royal Soc. Victoria, Melbourne, Vol. 70, Pt. 1, pp. 19-79, pls. 1-12.

(1960): Upper Mesozoic Microplankton from Australia and New Guinea; Palaeontology, Vol. 2, Pt. 2, pp. 243-261, pls. 37-39.

(1962): Additional microplankton from Australian Cretaceous sediments; Micropaleontology, Vol. 8, No. 4, pp. 485-507, pls. 1-7.

Corbett, C. S. (1955): In situ origin of McMurray oil of northeastern Alberta and its relevance to general problem of origin of oil (With discussions by Hume, G. S.; Gussow, W. C.; Hamilton, F. J.; Sproule, J. C.; and reply by Corbett, C. S.); Bull. Amer. Assoc. Petrol. Geol., Vol. 39, No. 8, pp. 1601-1649.

Couper, R. A. (1953): Upper Mesozoic and Cainozoic spores and pollen grains from New Zealand; New Zealand Geol. Surv., Paleont. Bull. 22, pp. 1-77, pls. 1-9.

(1958): British Mesozoic microspores and pollen grains, a systematic and stratigraphic study; Palaeontographica, Vol. 103, Pt. B, No. 4-6, pp. 75-179, pls. 15-31.

(1960): New Zealand Mesozoic and Cainozoic plant microfossils; New Zealand Geol. Surv., Paleont. Bull. 32, pp. 1-87, pls. 1-12.

Crickmay, C. H. (1931): Jurassic history of North America: its bearing on the development of continental structure; Proc. Amer. Phil. Soc., Vol. 70.

Davis, M. B., and Goodlett, J. (1960): Comparison of the present vegetation with pollen spectra in surface samples from Brownington Pond, Vermont; Ecology, Vol. 41, pp. 346-357.

Deflandre, G. (1934): Sur les microfossiles d'origine planctonique conservés à l'état de matière organique dans les silex de la craie; C. R. Acad. Sci., t. 199, pp. 966-968, figs. 1-11.

(1936): Microfossiles des Silex crétacés. Première Partie; Ann. Paleont., Vol. 25, pp. 151-191, pls. 1-10.

(1937): Microfossiles des Silex crétacés. Deuxième Partie; Ann. Paleont., Vol. 26, pp. 51-103, pls. 1-18.

-
- (1938): Sur le microplancton des mers jurassiques, conserve a l'etat de matiere organique dans les marnes de Villers-sur-mer; C. R. Acad. Sci., t. 206, pp. 687-689, figs. 1-6.
-
- (1947): Le Probleme des Hystrichospheres; Bulletin de l'Institut Oceanographique, No. 918, pp. 1-23.
- Delcourt, A., and Sprumont, G. (1955): Les spores et grains de pollen du Wealdien du Hainaut; Mem. Soc. Belg. Geol., n.s. 4 (5), pp. 1-73, pls. 1-4.
-
- (1957): Quelques microfossiles du Wealdien de Feron-Glageon; Bull. Soc. Belge. Geol. Paleontol. Hydrol., Brussels, Vol. 66, No. 1, pp. 57-70, pls. 1-3.
-
- (1959): Curieuse association de microfossiles dans le Wealdien de Feron-Glageon (France); Bull. Soc. Belge. Geol. Paleontol. Hydrol., Brussels, Vol. 68, No. 1, pp. 122-125.
- Delcourt, A. F., Dettmann, M. E., and Hughes, N. F. (1963): Revision of some Lower Cretaceous microspores from Belgium; Palaeontology, Vol. 6, Part 2, pp. 282-292, pls. 42-45.
- Deunff, J. (1958): Microorganismes planctoniques du Primaire armoricain; Bull. Soc. Geol. min. Bretagne, n.s., 2, pp. 1-41, pls. 1-12.
- Dijkstra, S. J. (1949): Megaspores and some other fossils from the Aachenian (Senonian) in South Limburg, Netherlands; Meded. Geol. Sticht., n.s. No. 3, pp. 19-32, pls. 1, 2.
-
- (1951): Wealden megaspores and their stratigraphical value; Netherlands, Meded. Geol. Sticht., n.s. No. 5, pp. 7-21, pls. 1-3.
- Downie, C. (1957): Microplankton from the Kimeridge Clay; Geol. Soc. London, Quart. Journ., Vol. 103, pp. 413-434, pl. 20.
- Downie, C., and Sarjeant, W.A.S. (1963): On the interpretation and status of some hystrichosphere genera; Palaeontology, Vol. 6, Pt. 1, pp. 83-96.
- Eisenack, A. (1958): Microplankton aus dem norddeutschen Apt; Neues Jb. Geol. Palaont., Abh., 106, pp. 383-422, pls. 21-27.
- Ellis, C. H., and Tschudy, R. H. (in press): Morphology and distribution of the Cretaceous megaspore genus Arcellites Miner, 1935 (Pyrobolospora Hughes, 1955); scheduled for publication: Micropaleontology, January, 1964.

- Erdtman, G. (1943): An introduction to pollen analysis; pp. 1-234; Chronica Botanica Company, Waltham, Mass., U.S.A.; Almqvist and Wiksell, Stockholm.
- _____ (1947): Suggestions for the classification of fossil and recent pollen grains and spores; Svensk. Bot. Tidskr., 41, pp. 104-114.
- _____ (1957): Pollen and spore morphology and plant taxonomy. Gymnospermae, Pteridophyta, Bryophyta. (An Introduction to Palynology. II); pp. 1-152, pls. 1-5, figs. 1-265, Almqvist and Wiksell, Stockholm; Ronald Press Company, New York.
- Evitt, W. R. (1961): Observations on the morphology of fossil dinoflagellates; Micropaleontology, Vol. 7, No. 4, pp. 385-420, pls. 1-9.
- Fægri, K. (1963): Organ-and form-genera: Significance and nomenclatural treatment; Taxon, Vol. 12, No. 1, pp. 20-28.
- Fægri, K., and Iversen, J. (1950): Textbook of modern pollen analysis; pp. 1-168, Copenhagen: Munksgaard.
- Funkhouser, J. W., and Evitt, W. R. (1959): Preparation techniques for acid-insoluble microfossils; Micropaleontology, Vol. 5, No. 3, pp. 369-375, text - figs. 1-2.
- Gignoux, M. (1955): Stratigraphic geology; W. H. Freeman and Company, San Francisco and London, pp. 1-682.
- Glaister, R. P. (1959): Lower Cretaceous of southern Alberta and adjoining areas; Bull. Amer. Assoc. Petrol. Geol., Vol. 43, No. 3, pp. 590-640.
- Gocht, H. (1957): Microplankton aus dem nordwestdeutschen Neokom (Teil 1); Palaont. Z., Vol. 31, No. 3/4, pp. 163-185, pls. 18-20.
- _____ (1959): Microplankton aus dem nordwestdeutschen Neokom (Teil 2); Palaont. Z., Vol. 33, No. 1/2, pp. 50-89, pls. 3-8.
- Goodman, A. J. (1951): Tectonics of east side of cordillera in western Canada; Bull. Amer. Assoc. Petrol. Geol., Vol. 35, No. 4, pp. 783-796.
- Grekoﬀ, N. (1953): Sur l'utilisation des microfaunes d'Ostracodes dans la stratigraphie precise du passage Jurassique - Cretace (Facies continentaux); Extrait de la Rev. de l'Institut. Franc. du Petrole et Ann. des Combustibles Liquides, Vol. 8, p. 362.

- Gries, J. P. (1954): Cretaceous rocks of Williston Basin; Bull. Amer. Assoc. Petrol. Geol., Vol. 38, No. 4, pp. 443-454.
- Groot, J. G., and Penny, J. S. (1960): Plant microfossils and age of non-marine Cretaceous sediments of Maryland and Delaware; Micropaleontology, Vol. 6, No. 2, pp. 225-236, pls. 1-2.
- Guennel, G. K. (1956): Systematic methods for Paleozoic plant microfossils; Micropaleontology, Vol. 2, No. 4, pp. 393-395.
- Gussow, W. C. (1960): Jurassic-Cretaceous boundary in western Canada and late Jurassic age of the Kootenay Formation; Royal Society of Canada, Vol. 54, Series 3, Section 4, pp. 45-64.
- Hall, J. W. (1962): Megaspores in the Dakota Formation (Cenomanian) of Iowa, U.S.A.; Manuscript of a paper presented in the palaeobotanical section of the A.I.B.S. congress in Corvallis, Oregon, U.S.A.
- Harris, T. M. (1961): The Yorkshire Jurassic flora, Part I; Memoir of the British Museum of Natural History.
- Hughes, N. F. (1955): Wealden plant microfossils; Geol. Mag., Vol. 92, pp. 201-217, pls. 10-12.
- _____ (1958): Palaeontological evidence for the age of the English Wealden; Geol. Mag., Vol. 95, pp. 41-49.
- _____ (1961): Further interpretation of Eucommiidites Erdtman, 1948; Palaeontology, Vol. 4, Pt. 2, pp. 292-299, pls. 37-38.
- Hume, G. S., and Hage, C. O. (1941): The geology of east-central Alberta; Geol. Surv. Can., Memoir 232.
- Hunt, C. W. (1950): Preliminary report on Whitemud oil field, Alberta, Canada; Bull. Amer. Assoc. Petrol. Geol., Vol. 34, No. 9, pp. 1795-1801.
- Ibrahim, A. (1933): Sporenformen des Aegirhorizonts des Ruhr-Reviers; Dissertation, Technische Hochschule zu Berlin, Privately pub. by Konrad Triltsch, Wurzburg, pp. 1-48.
- Imlay, R. W., and Reeside, J. B. Jr. (1954): Correlation of the Cretaceous Formations of Greenland and Alaska; Bull. Geol. Soc. Amer., Vol. 65, pp. 223-246.
- Iversen, J., and Troels-Smith, J. (1950): Pollenmorphologiske definitioner og typer; Danmarks Geol. Unders. IV. Raekke. 3, pp. 1-54.

- Jansonius, J. (1962): Palynology of Permian and Triassic sediments, Peace River area, western Canada; *Palaeontographica*, Vol. 110, Pt. B, No. 1-4, pp. 35-98, pls. 11-16.
- Jeffords, R. M., and Jones, D. H. (1959): Preparation of slides for spores and other microfossils; *Jour. Pal.*, Vol. 33, No. 2, pp. 344-347, text - fig. 1.
- de Jekhowsky, B. (1961): Sur Quelques Hystrichospheres Permo-Triasiques d'Europe et d'Afrique; *Revue de Micropaleontologie*, Vol. 3, No. 4, pp. 207-212, pls. 1, 2.
- Jeletzky, J. A. (1958): Uppermost Jurassic and Cretaceous rocks of Aklavik Range, Northeastern Richardson Mountains, Northwest Territories; *Geol. Surv. Can.*, Paper 58-2.
- Just, T. (1951): Mesozoic plant microfossils and their geologic significance; *Jour. Paleont.*, 25, pp. 729-735.
- Kedves, M. (1961): Etudes palynologiques dans le Bassin de Dorog - II ; Pollen et Spores, Vol. 3, No. 1, pp. 101-153, pls. 1-10.
- Klingspor, A. M. (1958): Jurassic Stratigraphy of the Sweetgrass Arch - Manitoba Section; *Amer. Assoc. Petrol. Geol.*, Jurassic and Carboniferous of Western Canada (Allan Memorial Volume), pp. 27-51.
- Knox, E. M. (1938): The spores of Pteridophyta, with observations on microspores in coals of Carboniferous age; *Trans. and Proc. Botan. Soc. Edinburgh*, 32, pp. 438-466.
- Kremp, G. O. W., and others (1957-1963): Catalog of fossil spores and pollen; Vols. 1, 2, 4, 8, 9, 10, 14, 15, 16, Pennsylvania State University, U.S.A.
- Kuyl, O. S., Muller, J., and Waterbolk, H. T. (1955): The application of palynology to oil geology with special reference to western Venezuela; *Geol. en Mijnb.*, n.s., Vol. 17, No. 3, pp. 49-76, pls. 1-4, text-figs. 1-7.
- Lanjouw, J., et al. (1961): International Code of Botanical Nomenclature, adopted by the Ninth International Botanical Congress, Montreal, 1959; International Bureau for Plant Taxonomy and Nomenclature of the International Association for Plant Taxonomy, Lange Nieuwstraat 106, Utrecht, Netherlands, pp. 1-372.
- Lantz, J. (1958a): Etude palynologique de quelques échantillons Mésozoïques du Dorset (Grande Bretagne); *Rev. Inst. Franc. Petrole*, Vol. 13, No. 6, pp. 917-943, pls. 1-7.

-
- (1958b): Etude des Spores et Pollens d'un echantillon Purbeckien de l'Ile d'Oleron; Rev. de Micropaleontologie, Vol. 1, No. 1, pp. 33-37, pl. 1.
- Layer, D. B., et al. (1949): Leduc oil field, Alberta, a Devonian coral reef discovery; Bull. Amer. Assoc. Petrol. Geol., Vol. 33, No. 4, pp. 572-602.
- Loranger, D. M. (1951): Useful Blairmore microfossil zone in central and southern Alberta, Canada; Bull. Amer. Assoc. Petrol. Geol., Vol. 35, No. 11, pp. 2348-2367.
-
- (1958): The Cretaceous/Jurassic contact in west-central Alberta; Guidebook, Eighth Annual Field Conference, Alta. Soc. Petr. Geol., pp. 29-38.
- Madler, K. (1954): Azolla aus dem Quartar and Tertiär sowie ihre Bedeutung für die Taxonomie älterer Sporen; Geol. Jb., 70, pp. 143-158.
- Maljavkina, V. S. (1953): Upper Triassic, Lower and Middle Jurassic spore-pollen complexes in east and west districts of the Ural Mountains Region; (V N I G R I), Trudy, All Union Petroleum Science Research, Geol. Surv. Inst., Moscow, n.s., Vol. 75, pp. 93-147, pls. 1-6.
-
- (1956): Spore-pollen complexes from Mesozoic deposits in the south-eastern regions of the Russian Platform (Emba and Western Urals); All Union Conf. Devel. Unified Scheme Stratigr. Mesozoic Dept. in Russian Platform, 1954, Trans. Leningrad, pp. 342-381, pls. 1-7.
-
- (1958): Spores and pollen of the Lower Cretaceous of the eastern Gobi Depression; (V N I G R I), Trudy, All Union Petroleum Science Research, Geol. Surv. Inst., Leningrad, No. 119, pp. 1-131, pls. 1-14.
- Manum, S. (1960): On the genus Pityosporites Seward, 1914; Nytt. Mag. Bot., Vol. 8, pp. 11-17, pl. 1.
- McConnell, R. G. (1893): Report on a portion of the District of Athabasca; Geol. Surv. Can. Rept. (New Series), Vol. 5, (1890-91), Part D.
- McLearn, F. H. (1917): Athabaska River section, Alberta; Geol. Surv. Can. Summ. Rept., 1916, pp. 145-151.
-
- (1932): Problems of the Lower Cretaceous of the Canadian interior; Trans. Roy. Soc. Can., Ser. 3, Vol. 26, Sec. 4, pp. 157-175.
-
- (1944): Revision of the paleogeography of the Lower Cretaceous of the western interior of Canada; Geol. Surv. Can. Paper 44-32.

-
- (1945): Revision of the Lower Cretaceous of the western interior of Canada (Second edition); Geol. Surv. Can. Paper 44-17.
- McLearn, F. H., et al. (1929): Mesozoic palaeontology of Blairmore Region, Alberta; Nat. Mus. Can., Bull. 58.
- Mellon, G. B. (1955): Age and origin of the McMurray Formation; Unpub. M.Sc. thesis, University of Alberta, Edmonton.
-
- (1959): The petrology of the Blairmore Group, Alberta, Canada; Unpub. Ph.D. thesis, Penn. State University.
- Mellon, G. B., and Wall, J. H. (1956): Geology of the McMurray Formation; Res. Council of Alberta, Report No. 72, pp. 1-43, pls. 1-4.
-
- (1961): Correlation of the Blairmore Group and equivalent strata; Edmonton Geol. Soc., Vol. 5, No. 1, pp. 1-11.
- Mellon, G. B., Wall, J. H., and Stelck, C. R. (1963): Lower Cretaceous section, Belcourt Ridge, northeastern British Columbia; Bull. Can. Petrol. Geol., Vol. 11, No. 1, pp. 64-72.
- Miner, E. L. (1935a): Paleobotanical examinations of Cretaceous and Tertiary coals, Part I, Cretaceous coals from Greenland; Amer. Midland Naturalist, Vol. 16, pp. 585-615.
-
- (1935b): Paleobotanical examinations of Cretaceous and Tertiary coals, Part II, Cretaceous and Tertiary coals from Montana; Amer. Midland Naturalist, Vol. 16, pp. 616-625.
- Muller, J. (1959): Palynology of Recent Orinoco delta and shelf sediments; Micropaleontology, Vol. 5, No. 1, pp. 1-32.
- Murray, N. (1939): The microflora of the Upper and Lower Estuarine Series of the East Midlands; Geol. Mag., Vol. 76, pp. 478-489, figs. 1-11.
- Naumova, S. N. (1937): Spores and pollen of the coals of the U.S.S.R.; 17th Int. Geol. Cong., Moscow, Abst. Papers, pp. 60-61.
- Nauss, A. W. (1945): Cretaceous stratigraphy of Vermilion area, Alberta, Canada; Bull. Amer. Assoc. Petrol. Geol., Vol. 29, No. 11, pp. 1605-1629.
-
- (1947): Cretaceous microfossils of the Vermilion area, Alberta; Jour. Paleont., Vol. 21, No. 4, pp. 329-343.
- Norem, W. L. (1954): Classification of spores and pollen for paleontologic classification; Jour. Sed. Petrol., Vol. 24, pp. 143-144.

- Pant, D. D. (1954): Suggestions for the classification and nomenclature of fossil spores and pollen grains; Bot. Rev., Vol. 20, pp. 33-60.
- Peck, R. E. (1941): Lower Cretaceous Rocky Mountain non-marine microfossils; Jour. Paleont., Vol. 15, No. 3, pp. 285-304.
- Pierce, R. L. (1961): Lower Upper Cretaceous Plant Microfossils from Minnesota; Minnesota Geological Survey, Bull. 42, pp. 1-86, pls. 1-3.
- Piveteau, J. (1952): Traite de Paleontologie; Vol. I, Masson, Paris.
- Pocock, S. A. J. (1959): Comparison of the Canadian and European Jurassic-Cretaceous boundaries by means of plant microfossils; Geol. Soc. Amer., Program Ann. Meeting Pittsburgh, p. 22 and in Oil in Canada Feb. 8, 1962, pp. 36-40.
- _____ (1961): The microspore genus Cingulatisporites Thomson, 1953; Jour. of Paleont., Vol. 36, No. 6, pp. 1234-1236.
- _____ (1962): Microfloral analysis and age determinations of strata at the Jurassic-Cretaceous boundary in the western Canada plains; Palaeontographica, Vol. 111, Pt. B, pp. 1-95, pls. 1-15.
- _____ (in press): Pollen and spores of the Chlamydospermidae and Schizaeaceae from Upper Mannville strata of the Saskatoon area of Saskatchewan; Grana Palynologica, Vol. 5.
- Pocock, S. A. J., and Jansonius, J. (1961): The pollen genus Classopollis Pflug, 1953; Micropaleontology, Vol. 7, No. 4, pp. 439-449, pl. 1.
- Potonie, R. (1952): Zur Systematik isolierter Sporen fossiler Pflanzen; Palynology, Aspects and Prospects-III, Svensk Bot. Tidskrift, Bd. 46, H. 2, pp. 158-173.
- _____ (1956): Synopsis der Gattungen der Sporae dispersae I. Sporites; Beih. Geol. Jb., Hannover, Heft 23, pp. 1-103, pls. 1-11.
- _____ (1958a): Synopsis der Gattungen der Sporae dispersae II. Sporites (Nachtrage), Saccites, Aletes, Praecolpates, Polypliates, Monocolpates; Beih. Geol. Jb., Hannover, Heft. 31, pp. 1-114, pls. 1-11.
- _____ (1958b): Views on spore nomenclature; Geol. Mag., Vol. 95, No. 6, pp. 491-496.
- _____ (1960): Synopsis der Gattungen der Sporae dispersae III. Nachtrage Sporites, Fortsetzung Pollenites Mit Generalregister zu Teil I-III; Beih. Geol. Jb., Hannover, Heft 39, pp. 1-189, pls. 1-9.

-
- (1962): Synopsis der Sporae in situ; Beih. Geol. Jb., Hannover, Heft 52, pp. 1-204, pls. 1-19.
- Potonie, R., and Gelletich, J. (1933): Über Pteridophytensporen einer eozanen Braunkohle aus Dorog in Ungarn; Sitzungsber. Ges. naturforsch. Freunde zu Berlin, Vol. 33, pp. 517-528, pls. 1,2.
- Potonie, R., and Kremp, G. (1954): Die Gattungen der palaeozoischen Sporae dispersae und ihre Stratigraphie; Geol. Jb., Vol. 69, pp. 111-194.
-
- (1955): Die Sporae dispersae des Ruhrkarbons, Teil I; Palaeontographica, Vol. 98, Pt. B, pp. 1-136.
-
- (1956a): Die Sporae dispersae des Ruhrkarbons, Teil II; Palaeontographica, Vol. 99, Pt. B, pp. 85-191.
-
- (1956b): Die Sporae dispersae des Ruhrkarbons, Teil III; Palaeontographica, Vol. 100, Pt. B, pp. 65-121.
- Potonie, R., Thomson, P. W., and Thiergart, F. (1950): Zur Nomenklatur und Klassifikation der neogenen Sporomorphae (Pollen und Sporen); Geol. Jahrb., 65, pp. 35-69.
- Radforth, N. W., and Rouse, G. E. (1954): The classification of recently discovered Cretaceous plant microfossils of potential importance to the stratigraphy of western Canadian coals; Can. J. Bot., Vol. 32, pp. 187-201, pl. 1.
- Raistrick, A. (1934): The correlation of coal seams by microspore content. Part I - The seams of Northumberland; Inst. Min. Eng. Trans., London, 88, pp. 142-153.
-
- (1935): The microspore analysis of coal; Naturalist, pp. 145-510.
-
- (1937): The microspores of coal and their use in correlation; Congres pour l'avancement des etudes de stratigraphie carbonifere, Heerlen, 1935, 2, pp. 909-917.
- Raistrick, A., and Simpson, J. (1933): The microspores of some Northumberland coals, and their use in the correlation of coal seams; Inst. Min. Eng. Trans., London, 85, pp. 225-235.
- Reeside, J. B. Jr. (1957): Paleoecology of the Cretaceous seas of the western interior of the United States; Geol. Soc. Amer., Memoir 67, Vol. 2, pp. 505-542.
- Ross, N. E. (1949): On a Cretaceous pollen and spore-bearing clay of Scania; Bull. Geol. Instn. Univ. Upsala, 34, pp. 25-43.

- Rouse, G. E. (1957): The application of a new nomenclatural approach to Upper Cretaceous plant microfossils from western Canada; *Can. J. Bot.*, Vol. 35, No. 3, pp. 349-375, pls. 1-3.
- _____ (1959): Plant microfossils from Kootenay coal-measures strata of British Columbia; *Micropaleontology*, Vol. 5, No. 3, pp. 303-324, pls. 1-2.
- Samojlovitch, S. R., and Mchedlishvili, N. D. (1961): Pollen and spores of western Siberia, Jurassic to Paleocene; *Transactions of the All Union Petroleum Science Research, Geol. Surv. Inst.*, Vol. 177, pp. 1-657, pls. 1-84 and 1-65.
- Schemel, M. (1950): Cretaceous plant microfossils from Iowa; *Amer. Jour. Bot.*, Vol. 37, pp. 750-754.
- Schopf, J. M., Wilson, L. R., and Bentall, R. (1944): An annotated synopsis of Paleozoic fossil spores and the definition of generic groups; *Illinois Geol. Surv., Report of Investigations No. 91*, pp. 1-73, pls. 1-3.
- Schuchert, C. (1923): Sites and nature of the North American geosynclines; *Bull. Geol. Soc. Amer.*, Vol. 34, pp. 151-230.
- Scott, R. A. (1960): Pollen of Ephedra from the Chinle Formation (Upper Triassic) and the genus Equisetosporites; *Micropaleontology*, Vol. 6, No. 3, pp. 271-276, pl. 1.
- Selling, O. H. (1944): Studies in the recent and fossil species Schizaea with particular reference to their spore characters; *Meddel. fran Goteborgs bot. Tradgard*, Vol. 16, pp. 1-112, pls. 1-5.
- Seward, A. C. (1895): Catalogue of the Mesozoic Plants in the British Museum (Natural History) - The Wealden Flora, Part 2.
- Spath, L. F. (1923-1943): A monograph of the Ammonoidea of the Gault; *Palaeontogr. Soc. (London)*, X + 787 p., 72 pl., 248 fig., 3 tables.
- _____ (1924): On the ammonites of the Speeton Clay and the subdivisions of the Neocomian; *Geol. Mag.*, Vol. 61, pp. 73-89.
- Staplin, F. L., et al. (1960): Palynological techniques for sediments; *Micropaleontology*, Vol. 6, No. 3, pp. 329-331.
- Steeves, M. W., and Barghoorn, E. S. (1959): The pollen of Ephedra; *Jour. Arnold Arb.*, Vol. 40, No. 3, pp. 221-255, pls. 1-4.
- Stelck, C. R. (1950): Cenomanian-Albian Foraminifera of western Canada; Unpub. Ph.D. thesis, Stanford University, California.

-
- (1958): Stratigraphic position of Viking Sand; Jour. Alta. Soc. Petrol. Geol., Vol. 6, No. 1, pp. 2-7.
- Stelck, C. R., Wall, J. H., Bahan, W. G., and Martin, L. J. (1956): Middle Albian Foraminifera from Athabasca and Peace River drainage areas of western Canada; Research Council Alta., Report No. 75.
- Stover, L. E. (1962): Tauocusporites, a new trilete spore genus from the Lower Cretaceous of Maryland; Micropaleontology, Vol. 8, No. 1, pp. 55-59, pl. 1.
- Strahan, A. (1898): Geology of the Isle of Purbeck and Weymouth; Mem. Geol. Surv., Britain.
- Thiergart, F. (1949): Der stratigraphische Wert mesozoischer Pollen und Sporen; Palaeontographica, Vol. 89, Pt. B, pp. 1-34, pls. 1-5.
-
- (1953): Uber einige Sporen und Pollen der Perutzer Schichten (Bohmen); Palaeontographica, Vol. 95, Pt. B, pp. 53-59, pl. 14.
- Thomson, P. W., and Pflug, H. (1953): Pollen und Sporen des mitteleuropaischen Tertiars; Palaeontographica, Vol. 94, Pt. B, pp. 1-138.
- Traverse, A. (1955): Pollen analysis of the Brandon Lignite of Vermont; U.S. Bur. Mines Rep. Invest. 5151, pp. 1-107, pls. 8-13.
-
- (1957): The nomenclatural problem of plant microfossil species belonging to extant genera; Micropaleontology, Vol. 3, No. 3, pp. 255-258.
-
- (1961): Effect of the 1959 International Botanical Congress on nomenclature of fossil spores and pollen; Micropaleontology, Vol. 7, No. 4, pp. 485-489.
- Tschudy, R. H. (1957): Pollen and spore formulae - A suggestion; Micropaleontology, Vol. 3, No. 3, pp. 277-280, tables 1-3.
- Valensi, L. (1953): Microfossiles des silex du Jurassique Moyen, Remarques petrographiques; Memoires de la Societe Geologique de France, Fasc. 4, Memoire No. 68, pp. 1-100, pls. 1-16.
- Van der Hammen, Th. (1954): Principios para la nomenclatura palynologica sistematica; Boletin Geologico, Columbia, 2, pp. 3-24.
- Warren, P. S., and Stelck, C. R. (1958): The Nikanassin-Luscar hiatus in the Canadian Rockies; Trans. Roy. Soc. Can., Vol. 52, Ser. 3, Sec. 4, pp. 53-62.

- Weyland, H., and Greifeld, G. (1953): Über strukturbietende Blatter und pflanzliche Mikrofossilien aus den Untersenonen Tonen der Gegend von Quedlinburg; *Palaeontographica*, Vol. 95, Pt. B, pp. 30-52, pls. 6-13.
- Weyland, H., and Krieger, W. (1953): Die Sporen und Pollen der Aachener Kreide and ihre Bedeutung für die Charakterisierung des Mittleren Senons; *Palaeontographica*, Vol. 95, Pt. B, pp. 6-29, pls. 1-5.
- White, W. H. (1959): Cordilleran tectonics in British Columbia; *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 43, No. 1, pp. 60-100.
- Wicher, C. A. (1940): Zur Stratigraphie der Grenzsichten Jura-Kreide Nordwestdeutschlands; *Oel u. Kohle*, Vol. 29, p. 263.
- Wickenden, R. T. D. (1948): The Lower Cretaceous of the Lloydminster oil and gas area, Alberta and Saskatchewan; *Geol. Surv. Canada*, Paper 48-21.
- _____ (1951): Some Lower Cretaceous sections on Peace River below the mouth of Smoky River, Alberta; *Geol. Surv. Can.*, Paper 51-16.
- Williams, G. D. C. (1960): The Mannville Group, central Alberta; Unpub. Ph.D. thesis, University of Alberta, Edmonton.
- Williams, G. K. (1958): Influence of the Peace River Arch on Mesozoic strata; *Jour. Alta. Soc. Petrol. Geol.*, Vol. 6, No. 3, pp. 74-81.
- Wilson, L. R. (1959): Geological history of the Gnetales; *Oklahoma Geol. Notes*, Vol. 19, No. 2, pp. 35-40, pl. 1.
- Wodehouse, R. P. (1933): Oil shales of the Green River Formation; *Bull. Torrey Bot. Club.*, 60, pp. 479-524.
- _____ (1935): *Pollen Grains*; McGraw Hill, New York and London.
- Wolberg, J. (1949): Zur Frage des Alters der obersten Wealdenschichten in England; *Neu. Jahr. f. Min., etc.*, Pt. B, No. 7, p. 193.
- _____ (1950): Vergleichende stratigraphische Untersuchungen der brackisch-limnischen Ablagerungen Europas an der Wende Jura-Kreide; *Geol. Landesanst.*, *Geol. Jahrb. f. 1943-1948*, No. 64, p. 159.
- Workman, L. E. (1958): Glauconitic sandstone in southern Alberta; *Jour. Alta. Soc. Petrol. Geol.*, Vol. 6, No. 10, pp. 237-245.
- _____ (1959): The Blairmore Group in the subsurface of Alberta; *Guidebook, Ninth Annual Field Conference, Alta. Soc. Petrol. Geol.*, pp. 122-129.

- Workman, L. E., et al. (1954): Lower Cretaceous of the Peace River region; Western Canada Sedimentary Basin, Amer. Assoc. Petrol. Geol., Tulsa, U.S.A., pp. 268-278.
- Yorath, C. J. (1962): Micropalaeontology of the Deer Bay Formation, Arctic Archipelago, Canada; Unpub. M.Sc. thesis, University of Alberta, Edmonton.
- Ziegler, W. H., and Pocock, S. A. J. (1960): The Minnes Formation; Edmonton Geol. Soc., Second Annual Field Conference Guide Book, pp. 43-71, pls. 1-3.

APPENDIX A

CORE DESCRIPTIONS

CORE DESCRIPTIONS

Imperial Namao No. 1 well

Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.

Elev. 2252' K.B.

Condensed from G. D. Williams (1960)

Core 4 3502-3518 Recovery 14'6"

Basal

4'3" SHALE, dark grey to black, with scattered silty bands and laminae.
Rest of the core is missing.

Core 5 3518-3522 Recovery 4'0"

4'0" SHALE, as above, with silty laminae becoming more common.

Core 6 3522-3540 Recovery 17'6"

4'9" SHALE, dark grey, micaceous, carbonaceous along bedding planes
with silty laminae and few ironstone beds.

12'9" SHALE, as above, interbedded with SANDSTONE and SILTSTONE,
light grey to light brown or "salt and pepper" in very low angle cross-
beds, glauconite and pyrite present.

Core 7 3540-3558 Recovery 16'3"

13'6" SANDSTONE, light to medium grey, fine-grained, "salt and pepper",
glauconitic, calcareous, and carbonaceous, banded and mottled with
SHALE, dark grey and carbonaceous. Patchy heavy oil staining.

2'9" SANDSTONE, dark brown, fine-grained, laminated and mottled with
SHALE, dark grey and carbonaceous. Stained with heavy oil.

Core 8 3558-3576 Recovery 16'3"

7'3" SHALE, dark grey, calcareous, pyritic, finely carbonaceous with
light grey silty beds and fossils of pelecypods and gastropods.

- 6'4" SANDSTONE, greyish brown, fine-grained, calcareous, slightly carbonaceous, oil stained, laminated and mottled with dark grey SHALE in the basal portion.
- 2'8" SHALE, medium grey, calcareous, grading to LIMESTONE, grey, fine-grained, partly argillaceous.

Core 9 3576-3594 Recovery 12'0"

- 5'6" LIMESTONE, medium grey, fine-grained, very argillaceous, grading to SHALE, medium grey and partly calcareous.
- 6'6" SHALE, dark grey, calcareous, slightly carbonaceous, irregularly interbedded with light grey SILTSTONE.

Core 10 3594-3612 Recovery 16'6"

- 3'6" SHALE, dark grey to black, silty, pyritic and carbonaceous, with fossils of pelecypods, gastropods and ostracodes.
- 1'0" COQUINA, greyish brown, consisting of pelecypods and gastropods.
- 7'6" SHALE, dark grey to black, calcareous, fossiliferous, pyritic with irregular silty laminae.
Part of the core is missing.

Core 11 3612-3630 Recovery 16'6"

- 11'6" SHALE, black, carbonaceous, calcareous, pyritic, with silty laminae near top, abundant fossils of ostracodes, pelecypods and gastropods.
- 5'0" SANDSTONE, light to medium grey, fine-grained, quartz with carbonaceous laminae, usually laminated with SHALE, dark grey, oil stained.

Core 12 3630-3640 Recovery 7'6"

- 6" SANDSTONE, and SHALE, as above.
- 1'0" SILTSTONE, light grey, quartz, argillaceous, laminated with coaly shale.
- 5'0" SANDSTONE, light brown, fine-to medium-grained, quartz, carbonaceous and micaceous on bedding planes, laminated with SHALE, dark grey, carbonaceous, and pyritic. Stained with heavy oil towards the top.

1'0" SHALE, dark grey to black, carbonaceous, silty with abundant plant fossils.

Core 13 3640-3658 Recovery 14'0"

2'6" SANDSTONE, light brown, fine-grained, quartz, carbonaceous, laminated with SHALE, dark grey, carbonaceous.

5'6" SHALE, dark grey to black, carbonaceous with plant fossils in the upper half grading to SILTSTONE, quartz, calcareous in the lower half.

6'0" SANDSTONE, light brown, very fine-grained to silty with laminae of SHALE, dark grey, carbonaceous and silty in the upper half, grading to fine-and medium-grained SANDSTONE, quartz, light grey in the lower half.

Core 14 3658-3676 Recovery 17'6"

11'0" SANDSTONE, light brown, fine-grained, quartz, partly carbonaceous, laminae of SHALE, dark grey, appear towards the base.

3'6" SHALE, dark grey, slightly carbonaceous, silty laminae at the top.

3'0" SANDSTONE, brown, fine-grained, quartz, slightly carbonaceous with shaly laminae.

Core 15 3676-3694 Recovery 17'0"

2'0" SANDSTONE, light greyish brown, very fine-grained to SILTSTONE, quartz, slightly carbonaceous, grading to SHALE, dark grey, silty, and carbonaceous.

2'0" COQUINA, brown, fossils of pelecypods and gastropods embedded in sideritic shale matrix.

13'0" SHALE, dark grey, carbonaceous, with silty and sandy laminae, showing slumping, slickensides etc.

Core 16 3694-3712 Recovery 7'6"

7'6" SHALE, dark grey, carbonaceous, silty with bands of siderite, laminated with SILTSTONE, light to medium grey, quartz, grading towards base to SANDSTONE, brown, fine-grained, quartz, partly calcareous and pyritic, slightly carbonaceous.

Core 17 3712-3730 Recovery 11'6"

11'6" SHALE, dark grey, showing slumping and other penecontemporaneous deformation, laminated with SILTSTONE to SANDSTONE as above, in the lower half.

Core 18 3730-3748 Recovery 14'0"

4'0" SHALE interbedded with SANDSTONE as in the lower half of Core 17.

10'0" SANDSTONE, light grey, fine-grained to medium-grained, quartz, pyritic, carbonaceous flecks, sparsely laminated with SHALE, grey, silty, carbonaceous.

Core 19 3748-3766 Recovery 11'0"

5'2" SANDSTONE, as above, with SHALE content increasing towards base.

2'8" SHALE, dark to brownish grey, carbonaceous, silty, sideritic, laminated with SILTSTONE, light grey, quartz, and few thin beds of SANDSTONE, medium grey, fine-grained, quartz, carbonaceous, pyritic.

3'2" SANDSTONE, light grey, fine-grained, quartz, carbonaceous, pyritic, sparsely laminated with SHALE, dark grey, carbonaceous, silty.

Core 20 3766-3784 Recovery 15'0"

1'6" SHALE, medium to dark grey, with carbonaceous flecks, silty, calcareous at base.

1'4" LIMESTONE, greyish brown, microcrystalline, argillaceous, grading to SHALE, light grey, silty, calcareous.

5'3" SHALE, medium to dark grey, carbonaceous, silty.

6'11" SHALE, dark grey, with scattered carbonaceous flecks, pyritic, interbedded with SILTSTONE, light grey, carbonaceous, pyritic.

Core 21 3850-3868 Recovery 16'0"

16'0" SHALE, medium to dark grey, carbonaceous, silty, blocky, thinly interbedded with SILTSTONE, light grey, quartz, contorted bedding, abundant pyrite nodules, grading to SANDSTONE, brown, very fine-grained, quartz, calcareous, sideritic.

Core 22 3868-3882 Recovery 11'6"

7'6" SHALE, as above with brecciated appearance, pyritic.

1'5" SILTSTONE, light grey, quartz, few shaly laminae, pyrite nodules abundant.

8" SANDSTONE, light grey, medium-to coarse-grained, quartz, "salt and pepper".

1'1" SANDSTONE, light brown, very fine-grained, quartz, with scattered chert pebbles, hard, dense.

Core 23 3887-3897 Recovery 9'0"

9'0" SHALE, light greyish green to bluish green, waxy, abundant quartz, and chert pebbles and pyrite nodules, brecciation and slickensides common.

Core 24 3897-3910 Recovery 4'6"

4'6" SHALE, bluish green, waxy, pyrite very abundant, with quartz and chert grains, slickensides common.

Anglo-Home-C. and E. Fort Augustus No. 1 well

Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.

Elev. 2068' K.B.

Core 33 2424-2433 Recovery 9'0". Top of Mannville Group at 2427'.

3'0" SHALE, dark grey, with a few silty laminae, fissile.

1'0" SILTSTONE, light brownish grey, micaceous, carbonaceous.

5'0" SANDSTONE, light grey, very fine-grained, argillaceous, many carbonaceous partings towards the top.

Core 34 2433-2442 Recovery 9'0"

9'0" SILTSTONE, light grey, laminated, with carbonaceous partings.

Core 35 2442-2451 Recovery 9'0"

9" SHALE, medium grey, silty, fissile.

6" SANDSTONE, light grey, fine-grained, carbonaceous, laminated.

1" BENTONITE bed, pale grey.

3'0" SHALE, medium grey to black, waxy, carbonaceous, with well preserved plant fossils, hard.

1'4" SANDSTONE, light grey, very fine-grained, argillaceous, laminated.

1'0" SHALE, dark grey to black, with a narrow coal band in middle, silty towards bottom.

2'4" SANDSTONE, light grey, kaolinitic, friable.

Core 36 2451-2460 Recovery 9'0"

4'0" SANDSTONE, friable.

5'0" SANDSTONE, light grey, kaolinitic, very fine-grained, hard, laminated with micaceous SILTSTONE and medium grey silty SHALE.

Core 37 2460-2469 Recovery 9'0"

- 7" SILTSTONE, black, laminated with black coaly SHALE, fissile.
- 4'10" SILTSTONE, light grey, hard, massive, laminated in the lower half with SANDSTONE, medium grey, fine-grained, calcareous.
- 3'7" SANDSTONE, light grey, micaceous, kaolinitic, very fine-grained, laminated, many carbonaceous partings.

Core 38 2469-2478 Recovery 9'0"

- 2'6" SANDSTONE, as above.
- 6'0" SILTSTONE, dark grey, carbonaceous, finely laminated, hard.
- 6" SHALE, medium grey, few coaly partings, with plant fossils, fissile.

Core 39 2478-2487 Recovery 7'0"

- 6" SHALE, medium grey, silty, carbonaceous, hard.
- 2'6" SHALE, black, coaly, soft, with bands of impure COAL.
- 4'0" SANDSTONE, light grey, fine-grained, kaolinitic, carbonaceous towards bottom, friable.

Core 40 2487-2496 Recovery 9'0"

- 9'0" SANDSTONE, as above, becoming harder, laminated, and silty towards bottom.

Core 41 2496-2505 Recovery 9'0"

- 4'6" SILTSTONE, medium grey, finely laminated with silty SHALE and silty SANDSTONE.
- 2'0" SHALE, dark grey, fissile, laminated with SILTSTONE and fine-grained SANDSTONE.
- 2'6" SHALE, dark grey, silty, carbonaceous, non-fissile.

Core 42 2505-2514 Recovery 6'0"

- 6" COAL, fissile, soft, shale partings towards bottom.

2'0" SHALE, medium grey, silty, carbonaceous flecks, with a thin bed of coaly SHALE in the middle.

3'6" SHALE, black, coaly, fissile, with many bands of COAL.

Core 43 2514-2523 Recovery 9'0"

2'0" COAL, fissile, soft, shaly towards bottom.

4'0" SHALE, medium grey, silty, non-fissile, laminated with silty and sandy partings towards bottom, hard, contains well preserved plant fossils.

3'0" SANDSTONE, light grey, fine-grained, carbonaceous, hard.

Core 44 2523-2532 Recovery 9'0"

4'0" SANDSTONE, as above.

3'0" SILTSTONE, medium grey, laminated with SHALE.

2'0" SHALE, medium grey, hard, laminated, silty, with some plant fossils.

Core 45 2532-2535 Recovery 1'0"

1'0" SHALE, medium grey, hard, non-fissile, with abundant and well preserved plant fossils.

Core 46 2535-2544 Recovery 9'0"

1'0" SHALE, as above.

8'0" SHALE, light grey, finely laminated, silty, hard, non-fissile, with some plant fossils.

Core 47 2544-2553 Recovery 9'0"

6'6" SILTSTONE, medium grey, calcareous, laminated, shaly.

2'6" SANDSTONE, light grey, silty, laminated, carbonaceous, with abundant and well preserved plant fossils.

Core 48 2553-2562 Recovery 9'0"

2'0" SHALE, medium grey, hard, non-fissile, with abundant and well preserved plant fossils.

7'0" SANDSTONE, light grey, fine-grained, carbonaceous, laminated, hard.

Core 49 2562-2571 Recovery 9'0"

6" SHALE, dark grey, hard, fissile.

8'0" SHALE, medium grey, very silty, poorly laminated, hard, carbonaceous flecks.

6" SANDSTONE, light grey, very fine-grained.

Core 50 2571-2580 Recovery 9'0"

3'0" SANDSTONE, light grey, very fine-grained, carbonaceous, micaceous, hard.

4'0" SILTSTONE, medium grey, hard, massive.

2'0" SHALE, medium grey, carbonaceous, hard, ironstone band.

Core 51 2580-2589 Recovery 9'0"

2'6" SANDSTONE, light grey, silty, laminated.

6'6" SANDSTONE, whitish, medium-grained, kaolinitic, friable towards top, calcareous in middle, fine-grained and silty towards bottom.

Core 52 2589-2598 Recovery 9'0"

6'0" SANDSTONE, as above.

3'0" SILTSTONE, whitish, laminated, with shaly and carbonaceous partings.

Core 53 2598-2607 Recovery 9'0"

3'0" SILTSTONE, as above.

- 2" SANDSTONE, whitish, friable.
- 8" SHALE, medium grey, fissile, hard.
- 6" SILTSTONE, light grey, laminated, hard.
- 2'8" SHALE, medium grey, fissile, pyritic.
- 2'0" SILTSTONE, light green, massive, grades into SHALE, light greenish grey, with abundant and well preserved plant fossils towards bottom.

Core 54 2607-2616 Recovery 9'0"

- 1'9" COAL, and coaly SHALE, fissile.
- 9" SHALE, greenish grey, with carbonaceous flecks.
- 1'6" SILTSTONE, light grey, carbonaceous, hard, massive.
- 4" SHALE, black, coaly, fissile.
- 1'8" SHALE, medium grey, silty in part, hard, non-fissile, with plant fossils, becomes waxy towards bottom.
- 3'0" SILTSTONE, light grey, sandy, carbonaceous, hard, massive.

Core 55 2616-2625 Recovery 4'6"

- 4'6" SILTSTONE, medium grey, sandy, carbonaceous, hard, massive, with a few laminae of whitish SANDSTONE.

Core 56 2625-2634 Recovery 6'0"

- 6'0" SILTSTONE, medium grey, with ironstone bands, hard, massive.

Core 57 2634-2643 Recovery 9'0"

- 2'4" SHALE, medium grey, hard, massive, with plant fossils.
- 3'8" SANDSTONE, whitish, laminated, carbonaceous, silty, friable.
- 2'0" SILTSTONE, light grey, with some sandy lenses, hard, massive.

1'0" SHALE, light grey, hard, non-fissile, with silty and ironstone partings.

Core 58 2643-2648 Recovery 2'0"

2'0" SHALE, medium grey, silty, with ironstone partings.

Core 59 2648-2657 Recovery 9'0"

1'6" SHALE, medium grey, silty, laminated, hard.

2'0" SHALE, black, silty, carbonaceous, fissile, hard.

1'10" SHALE, black, coaly, COAL band near bottom.

8" SILTSTONE, medium grey, hard, massive.

3'0" SANDSTONE, whitish, fine-grained, friable.

Core 60 2657-2662 Recovery 5'0"

5'0" SANDSTONE, as above, near the top grades into light grey, medium-to coarse-grained, calcareous, hard, SANDSTONE, with carbonaceous partings.

Core 61 2662-2671 Recovery 7'0"

4'0" SILTSTONE, light grey, laminated with SHALE and SANDSTONE, hard.

3'0" SILTSTONE, as above, with calcareous and ironstone bands.

Core 62 2671-2680 Recovery 9'0"

9'0" SHALE, medium grey, silty laminae, core badly broken up.

Core 63 2680-2689 Recovery 7'6"

7'6" SANDSTONE, light greyish brown, glauconitic, fine-to medium-grained, calcareous and hard towards top, the rest is friable, slightly oil stained.

Core 64 2689-~~2699~~ Recovery 9'0"

6'0" SHALE, medium grey, silty, hard, non-fissile, with ironstone bands.

3'0" SILTSTONE, whitish, hard, laminated with medium grey silty SHALE.

Core 65 2699-2708 Recovery 9'0"

7'0" SILTSTONE, light grey, hard, laminated with SHALE.

1'6" SHALE, medium grey, silty, hard, non-fissile.

6" SILTSTONE, light grey, hard, laminated with SHALE.

Core 66 2708-2717 Recovery 9'0"

9'0" SHALE, medium grey, with white silty laminae and ironstone bands.

Core 67 2717-2725 Recovery 9'0"

2'0" SHALE, as above.

2'0" SHALE, medium grey, hard.

4'6" SHALE, medium to dark grey, sandy towards top and glauconitic towards bottom.

6" SANDSTONE, light brown, medium-grained, friable, slightly oil stained.

Core 68 2725-2734 Recovery 9'0"

9'0" SANDSTONE, light brown, fine-grained, kaolinitic, glauconitic, massive, friable, slightly oil stained.

Core 69 2734-2743 Recovery 9'0"

1'6" SANDSTONE, light brownish grey, fine-grained, silty, with SHALE partings, glauconitic and calcareous towards top.

4'6" SHALE, medium to dark grey, silty towards bottom, fissile.

3'0" SILTSTONE, medium grey, laminated, with white SANDSTONE and silty SHALE partings.

Core 70 2743-2752 Recovery 8'0"

2'0" SHALE, greyish brown, silty, hard, non-fissile.

6'0" SANDSTONE, light grey to brown, medium-grained, micaceous, with calcareous bands, slightly oil stained.

Core 71 2752-2761 Recovery 7'0"

7'0" SANDSTONE, as above.

Core 72 2761-2770 Recovery 9'0"

9'0" SANDSTONE, light brown, fine-grained, with carbonaceous partings, slightly oil stained.

Core 73 2770-2779 Recovery 7'0"

5'6" SANDSTONE, as above.

1'6" SANDSTONE, light grey, fine-grained, calcareous, glauconitic, hard.

Core 74 2779-2788 Recovery 9'0"

1'6" SANDSTONE, as above.

7'6" SANDSTONE, light brown, fine-grained, micaceous, glauconitic, friable, slightly oil stained.

Core 75 2788-2797 Recovery 9'0"

9'0" SANDSTONE, as above.

Core 76 2797-2798 Recovery 1'0"

1'0" SANDSTONE, dark brown, medium-grained, hard, massive, oil stained.

Core 77 2798-2808 Recovery 2'0"

2'0" SANDSTONE, light grey, fine-grained, calcareous, glauconitic, pyritic, hard, massive.

Core 78 2808-2815 Recovery 7'0"

3'0" SANDSTONE, light brown, fine-grained, laminated.

4'0" SANDSTONE, light brown, fine-grained, silty, laminated with silty SHALE towards bottom, several carbonaceous partings, slightly oil stained.

Core 79 2815-2824 Recovery 9'0"

1'0" SILTSTONE, light brown to grey, laminated with silty SHALE partings, carbonaceous, hard.

1'6" SHALE, medium grey, waxy, with silty laminae and ironstone bands, fissile.

6'6" SILTSTONE, light grey, laminated with silty SHALE, grades into white, laminated, silty, SANDSTONE towards bottom.

Core 80 2824-2833 Recovery 9'0"

9'0" SANDSTONE, light grey, fine-grained, laminated, hard, with silty SHALE partings in the lower half, carbonaceous.

Core 81 2833-2842 Recovery 9'0"

3'6" SILTSTONE, light grey, laminated with silty SHALE, hard.

3'0" SANDSTONE, light grey, fine-grained, silty, calcareous, hard.

2'6" SILTSTONE, medium grey, laminated with medium to dark grey, carbonaceous, SHALE.

Core 82 2842-2851 Recovery 9'0"

9'0" SILTSTONE, light grey, laminated with dark grey silty SHALE with an increase in shale content towards the lower end, some sand lenses in the upper portion.

Core 83 2851-2860 Recovery 9'0"

9'0" SILTSTONE, as above.

Core 84 2860-2869 Recovery 9'0"

6'6" SHALE, medium to dark grey, laminated with SILTSTONE towards the lower end, hard, fissile.

2'6" SANDSTONE, light grey, fine-grained, glauconitic, silty, laminated with dark grey, silty SHALE towards the lower end.

Core 85 2869-2878 Recovery 9'0"

8'6" SHALE, black, laminated with grey, SILTSTONE, fissile.

6" SANDSTONE, greenish grey, fine-to medium-grained, glauconitic, carbonaceous, hard.

Core 86 2878-2887 Recovery 9'0"

9'0" SANDSTONE, greenish grey, with deep green bands, very fine-grained, glauconitic, calcareous, micaceous, with a few dark grey SHALE partings, slightly oil stained.

Core 87 2887-2896 Recovery 7'6"

7'6" SANDSTONE, as above.

Core 88 2896-2905 Recovery 9'0"

4'0" SANDSTONE, as above.

5'0" SILTSTONE, dark brown, laminated with SHALE, non-glauconitic.

Core 89 2905-2914 Recovery 9'0"

9'0" SILTSTONE, whitish, quartz, kaolinitic, micaceous, laminated with dark grey silty SHALE, with carbonaceous flecks.

Core 90 2914-2923 Recovery 9'0"

9'0" SILTSTONE, as above. Laminations destroyed.

Core 91 2923-2932 Recovery 9'0"

9'0" SILTSTONE, as above. Laminations destroyed by burrowing.

Core 92 2932-2938 Recovery 6'0"

6'0" SILTSTONE, as above. Laminations not disturbed in the lower portion.

Core 93 2938-2947 Recovery 6'0"

6'0" SILTSTONE, light grey, quartz, laminated with black SHALE, a few lenses of whitish quartz SANDSTONE, calcareous in lower half, slightly oil stained.

Core 94 2947-2956 Recovery 9'0"

6" SHALE, black, laminated with SILTSTONE, fossils of ostracodes.

2'0" SILTSTONE, medium grey, laminated with fine-grained SANDSTONE.

6'6" SILTSTONE, medium grey, finely laminated with dark grey silty SHALE, partly calcareous.

Core 95 2956-2965 Recovery 9'0"

9'0" SILTSTONE, as above. Finely laminated, less silty, with fossils of pelecypods and ostracodes.

Core 96 2965-2974 Recovery 9'0"

9'0" SHALE, black, calcareous, silty bands, fissile, fossils of ostracodes.

Core 97 2974-2983 Recovery 9'0"

9'0" SHALE, as above. Fossils of pelecypods, gastropods, and ostracodes, a narrow band of light brown, very fine-grained, calcareous, SANDSTONE, at the bottom.

Core 98 2983-2992 Recovery 9'0"

9'0" SILTSTONE, light brown, finely laminated with dark grey, silty SHALE, a band of light brown, very fine-grained, friable SANDSTONE at 2989-2991, slightly oil stained.

Core 99 2992-3001 Recovery 4'0"

1'6" SILTSTONE, as above.

2'6" SILTSTONE, light grey, slumped, grading into light brown, very fine-grained, friable SANDSTONE, slightly oil stained.

Core 100 3001-3010 Recovery 7'0"

1'0" SANDSTONE, light brown, silty, with carbonaceous flecks.

3'0" SANDSTONE, light brown, argillaceous, carbonaceous, laminated with medium grey SILTSTONE and dark grey silty SHALE.

3'0" SANDSTONE, light brown, silty.

Core 101 3010-3019 Recovery 9'0"

3'6" SANDSTONE, light brown, very fine-grained, friable, silty.

6" SHALE, dark grey, silty, non-fissile, hard, with carbonaceous flecks.

5'0" SANDSTONE, light brown, silty, friable.

Core 102 3019-3028 Recovery 9'0"

9'0" SANDSTONE, light brown, silty, friable, grades into SILTSTONE, with scattered dark shaly blebs, oil stained.

Core 103 3028-3037 Recovery 3'0"

3" IRONSTONE.

2'9" SHALE, dark grey, silty, fissile, grades into light grey SILTSTONE.

Core 104 3037-3046 Recovery 6'0"

1'6" SILTSTONE, medium grey, with dark silty SHALE, grades into light brown, silty, SANDSTONE.

4'6" SANDSTONE, light brown, silty, friable, with some hard silty bands.

- Core 105 3046-3054 Recovery 6'0"
- 6'0" SANDSTONE, as above.
- Core 106 3054-3062 Recovery 7'0"
- 1'0" SHALE, dark grey, silty, hard, laminated with light brown SILTSTONE and friable, very fine-grained SANDSTONE.
- 6'0" SANDSTONE, light brown, quartz, micaceous, very fine-grained, friable.
- Core 107 3062-3066 Recovery 4'0"
- 4'0" SANDSTONE, as above, with thick bands of SILTSTONE and dark, silty, SHALE.
- Core 108 3066-3075 Recovery 8'0"
- 8'0" SANDSTONE, as above.
- Core 109 3075-3084 Recovery 8'0"
- 2'10" SANDSTONE, light brown, medium-to coarse-grained, quartz, with a few laminae of dark silty SHALE.
- 3" IRONSTONE.
- 3'4" SILTSTONE, medium grey, grades into dark grey silty SHALE and light grey silty SANDSTONE.
- 10" SHALE, dark grey, hard, waxy.
- 9" SANDSTONE, mottled brown and white, fine-grained, friable.
- Core 110 3084-3093 Recovery 8'0"
- 3'4" SANDSTONE, light brown, fine-grained, friable.
- 2'4" SILTSTONE, medium grey, hard, grades into dark grey silty SHALE and light grey silty SANDSTONE.

8" SHALE, dark grey, hard.

1'8" SILTSTONE, light grey, hard, massive, with a few dark SHALE laminae.

Core 111 3093-3102 Recovery 9'0"

4'6" SILTSTONE, light brown, friable in part, interbedded with silty SANDSTONE.

2'3" SHALE, dark grey, hard, non-fissile, grades to whitish, laminated, carbonaceous, friable, SILTSTONE.

2'3" SHALE, as above.

Core 112 3102-3111 Recovery 1'0"

1'0" SILTSTONE, whitish, massive, hard.

Core 113 Core missing.

Core 114 3111-3120 Recovery 9'0"

9'0" SANDSTONE, light brown, very fine-grained, quartz, micaceous, friable, with laminae of dark silty SHALE and light grey SILTSTONE.

Core 115 3120-3129 Recovery 3'0"

3'0" SANDSTONE, whitish, fine-grained, friable.

Core 116 3129-3138 Recovery 9'0"

9'0" SANDSTONE, light brown, fine-grained, quartz, micaceous, friable.

Core 117 3138-3147 Recovery 9'0"

9'0" SANDSTONE, as above.

Core 118 3147-3156 Recovery 8'0"

8'0" SANDSTONE, light brown, medium-to coarse-grained, quartz, slightly calcareous in the lower portion.

Core 119 3156-3165 Recovery 9'0"

3'4" SHALE, dark grey, hard, non-fissile, with few silty laminae.

5'8" SILTSTONE, medium grey, "salt and pepper", laminated with dark silty SHALE and fine-grained SANDSTONE.

Core 120 3165-3174 Recovery 8'0"

1'6" SILTSTONE, dark grey, calcareous, hard, with partings of silty SHALE.

3'0" SANDSTONE, light brown to grey, fine-to medium-grained, "salt and pepper", calcareous, friable in part.

3'6" SILTSTONE, light brownish grey, calcareous, hard, laminated, grades into SHALE, dark brown, calcareous, silty, slightly oil stained.

Core 121 3174-3179 Recovery 5'0"

3'0" SHALE, dark brown, calcareous, hard, non-fissile.

2'0" SHALE, black, waxy, hard, non-fissile, with ironstone band at bottom.

Core 122 3179-3188 Recovery 6'0"

4'0" SHALE, as above, calcareous in part.

1'10" SHALE, as above, carbonaceous and pyritic, ironstone bands.

2" SILTSTONE, whitish, quartz, kaolinitic, friable, massive.

Core 123 3188-3197 Recovery 6'0"

1'6" SILTSTONE, as above.

1'6" SILTSTONE, dirty brownish grey.

3'0" SHALE, dark brown, hard, non-fissile.

Core 124 3197-3204 Recovery 5'0"

2'0" SHALE, dark brown, hard, grades into black, fissile SHALE towards bottom.

1'6" SANDSTONE, light brown, friable.

1'6" SANDSTONE, light grey, silty, friable, grading into dark brown SILTSTONE and silty SHALE.

Core 125 3204-3213 Recovery 6'0"

1'4" SHALE, dark brown, silty, sandy towards bottom.

4'8" SANDSTONE, whitish, quartz, kaolinitic, fine-grained, friable.

Core 126 3213-3222 Recovery 7'0"

3'6" SHALE, medium brownish grey, waxy, hard, sandy towards bottom.

1'0" SILTSTONE, earthy white, massive.

2'6" SHALE, medium brownish grey, waxy, hard, slickensides common.

Core 127 3222-3231 Recovery 9'0"

7'0" SHALE, dark brown, hard, waxy, silty and carbonaceous in the lower part.

2'0" SILTSTONE, earthy white, friable.

Core 128 3231-3240 Recovery 4'0"

6" SILTSTONE, brown, hard, massive.

2'0" SANDSTONE, earthy white, quartz, kaolinitic, silty, friable.

1'6" SHALE, dark brown, hard, non-fissile, silty towards bottom.

Core 129 3240-3249 Recovery 9'0"

6" SILTSTONE, light grey to white, hard.

6'6" SHALE, medium brownish grey, with carbonaceous flecks.

2'0" SANDSTONE, whitish, fine-grained, quartz, kaolinitic, silty, friable.

Core 130 3249-3257 Recovery 5'0"

5'0" SILTSTONE, light grey to white, quartz, friable, a few shaly partings, sandy towards bottom.

Core 131 3257-3266 Recovery 9'0"

9'0" SANDSTONE, whitish, fine-grained, quartz, kaolinitic, friable, very silty, many carbonaceous partings towards bottom.

Core 132 3266-3275 Recovery 9'0"

9'0" SHALE, light green to bluish green, silty, hard, non-fissile.

Core 133 3275-3284 Recovery 9'0" Base of Mannville Group at 3281'

6'0" SHALE, as above.

3'0" DOLOMITE, light brown, hard, fine-grained, crystalline, pyritic.

Imperial Willingdon No. 1 well

Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.

Elev. 2078' K.B.

Core 9 1770-1785 Top of Mannville Group at 1781'

Basal

4'0"

SANDSTONE, light grey, coarse-to medium-grained, with carbonaceous flecks, "salt and pepper" with brown sideritic specks, friable, grades towards top into SHALE, medium grey, silty, hard, non-fissile with some plant fragments.

Core 10 1785-1804 Recovery 19'0"

2'0"

SANDSTONE, as above.

4'6"

SHALE, dark grey to black, slightly silty, non-fissile, with carbonaceous flecks and badly preserved plant fossils.

6"

COAL band and shaly coal.

4"

SHALE, light grey, silty, non-fissile.

11'8"

SILTSTONE, light to medium grey, thinly laminated with SHALE, dark grey, silty, carbonaceous partings common, friable.

Core 11 1804-1816 Recovery 9'6"

6'0"

SANDSTONE, light grey, "salt and pepper" with brown sideritic specks, coarse-to medium-grained, with carbonaceous flecks, very friable.

1'0"

SHALE, light grey, waxy, silty, non-fissile.

2'6"

SILTSTONE, light grey, massive with ironstone concretions.

Core 12 1816-1836 Recovery 16'0"

8'6"

SHALE, medium to dark grey, slightly silty, fissile with silty laminae, some bands of ironstone.

2'6"

SHALE, black, highly carbonaceous, hard, non-fissile.

- 6" COAL band with some coaly shale.
- 2'0" SILTSTONE, dark grey, highly carbonaceous, with ironstone concretions.
- 6" COAL band with some coaly shale.
- 1'0" SILTSTONE, black, highly carbonaceous, with some ironstone concretions and numerous plant fragments.
- 1'0" SHALE, light grey, silty, hard, non-fissile.

Core 13 1836-1856 Recovery 17'0"

- 3'0" SHALE, medium grey, silty, with scattered carbonaceous flecks, non-fissile.
- 2'0" SHALE, dark grey, hard, carbonaceous, non-fissile.
- 6" SHALE, black, coaly, non-fissile.
- 1'0" SHALE, dark grey, hard, non-fissile.
- 1'0" SHALE, medium grey, silty, with ironstone band and scattered carbonaceous flecks.
- 2'0" SILTSTONE, light grey, hard with carbonaceous flecks.
- 2'6" SHALE, medium grey, silty, with carbonaceous flecks and ironstone concretions.
- 6" COAL band with some coaly shale.
- 4'6" SANDSTONE, light grey, "salt and pepper", fine-to medium-grained, with carbonaceous flecks, laminated with SILTSTONE and silty SHALE.

Core 14 1856-1867 Recovery 9'0"

- 4" SHALE, medium grey, silty, with carbonaceous flecks, hard, non-fissile.
- 4" SILTSTONE, light grey, hard, with carbonaceous flecks.

- 10" SANDSTONE, light grey, fine-to medium-grained, calcareous, with carbonaceous flecks, friable.
- 6" SILTSTONE, light grey, hard, with scattered carbonaceous flecks.
- 4" SANDSTONE, light grey, fine-to medium-grained, "salt and pepper", calcareous, friable.
- 1'8" SILTSTONE, light grey, hard, with scattered carbonaceous flecks.
- 1'6" SANDSTONE, light grey, medium-grained, calcareous, "salt and pepper", with scattered carbonaceous flecks, friable.
- 3'0" SHALE, medium grey, more silty towards the top, with scattered carbonaceous flecks and some ironstone concretions, non-fissile.

Core 15 1867-1881 Recovery 5'0" Scrambled.

- 1'0" SHALE, light grey, silty, with scattered carbonaceous flecks.
- 6" SANDSTONE, light grey, medium-grained, with carbonaceous flecks, friable.
- 3'6" SHALE, dark grey to black, non-fissile, with coal bands and abundant plant fossils.

Core 16 1881-1899 Recovery 18'0"

- 1'0" SHALE, dark black, with coaly partings, hard, fissile.
- 2'0" SHALE, light grey, silty laminae, with carbonaceous flecks, slumped.
- 1'6" COAL band with coaly shale.
- 1'0" SHALE, black, with coaly partings, hard, fissile.
- 4" SILTSTONE, light grey, laminated with SHALE, with carbonaceous flecks.
- 5" SANDSTONE, light grey, medium-grained, "salt and pepper", hard, with carbonaceous flecks.
- 7'3" SILTSTONE, light grey, laminated with SHALE and fine-grained SANDSTONE, numerous ironstone bands.

- 1'0" SHALE, black, with coaly partings, hard.
- 3'0" SILTSTONE, dark grey, carbonaceous.
- 6" SANDSTONE, medium grey, medium-to coarse-grained, with coaly partings towards top and impregnated with heavy oil towards the bottom, friable.

Core 17 1899-1918 Recovery 18'0"

- 1'0" SANDSTONE, light grey, "salt and pepper", fine-grained, laminated with SILTSTONE AND SHALE, slightly oil stained, friable.
- 1'0" SANDSTONE, as above, but heavily impregnated with crude oil.
- 11'6" SANDSTONE, light grey, fine-grained, laminated with SILTSTONE and SHALE, "salt and pepper", slightly oil stained, friable.
- 2'0" LIMESTONE, light grey to light brown, microcrystalline, hard.
- 2'6" SILTSTONE, medium grey, laminated with SHALE and fine-grained SANDSTONE, carbonaceous flecks.

Core 18 1918-1922 Recovery 2'6"

- 2'6" SHALE, dark grey to black, micaceous, silty towards top, fissile.

Core 19 1922-1938 Recovery 16'0"

- 4'6" SILTSTONE, light grey, micaceous, laminated with SHALE, black, carbonaceous, and SANDSTONE, fine-grained, brown, and oil impregnated.
- 6" SANDSTONE, light grey, fine-to medium-grained, calcareous, with large dispersed pieces of carbonaceous material, hard.
- 2'0" SILTSTONE, as above.
- 6" SHALE, light grey, silty, micaceous, fissile.
- 4'0" SILTSTONE, brown, laminated with fine-grained SANDSTONE, some shaly partings also present, heavily impregnated with crude oil.
- 2'6" SHALE, light grey, silty, micaceous, some ironstone concretions, fissile.

2'0" SILTSTONE, light grey, micaceous, laminated with fine-grained SANDSTONE, slightly oil stained.

Core 20 1938-1956 Recovery 17'6"

6" SANDSTONE, light brown, fine-grained, laminated with silt, slightly oil stained.

2'0" SHALE, dark grey to black, micaceous, laminated with SILTSTONE and fine-grained SANDSTONE, fissile.

2'0" SILTSTONE, dark grey, micaceous, interbedded with SHALE.

2'6" SILTSTONE, light grey, micaceous, laminated with fine-grained SANDSTONE.

10'6" SILTSTONE, light grey, micaceous, interbedded with thick beds of fine-grained SANDSTONE, one ironstone band near the base.

Core 21 1956-1975 Recovery 16'6"

1'0" SHALE, medium grey, silty, with thin ironstone bands, fissile.

8'6" SILTSTONE, light grey, micaceous, laminated with SHALE and fine-grained SANDSTONE.

3'0" LIMESTONE, dark grey to light pink, microcrystalline, compact, a few bands of pure white calcite, hard.

4'0" SILTSTONE, as above, with some bands of ironstone, grades to SHALE towards bottom.

Core 22 1975-1994 Recovery 15'6"

4'0" SHALE, medium grey, micaceous, laminated with SILTSTONE towards top, with carbonaceous flecks, fissile.

4'6" SANDSTONE, light grey, fine-to medium-grained, laminated with SILTSTONE, with carbonaceous flecks and pyrite nodules.

3'0" SANDSTONE, greyish brown, "salt and pepper", with brown speckles, medium-to coarse-grained, carbonaceous, calcareous, compact.

4'0" SILTSTONE, light grey, laminated with fine-grained SANDSTONE, argillaceous.

Core 23 1994-2013 Core missing.

Core 24 2013-2026 Recovery 12'6"

1'0" SILTSTONE, as above.

7'0" SANDSTONE, light to medium grey, "salt and pepper", with brown speckles, medium-to coarse-grained, argillaceous.

6" SHALE, black, silty, carbonaceous.

3'6" SANDSTONE, as above, becoming increasingly silty and mottled with black carbonaceous SHALE towards bottom.

Core 25 2026-2045 Recovery 10'0"

6'6" SHALE, dark grey to black, micaceous, silty towards the top and bottom, with pyrite nodules, fissile.

3'6" SHALE, light grey to medium grey, laminated with SILTSTONE, increasingly silty towards bottom.

Core 26 2045-2063 Recovery 18'0"

1'0" SHALE, medium grey, laminated with SILTSTONE.

6" IRONSTONE band.

8'0" SHALE, medium grey to dark grey, silty, micaceous, with pyrite nodules, fissile.

3'6" SILTSTONE, medium grey, highly glauconitic, abundant pyrite nodules, laminated with SHALE.

5'0" SANDSTONE, light grey, slightly glauconitic in places, quartz, fine-grained, argillaceous, friable.

Core 27 2063-2082 Recovery 17'6"

11'0" SANDSTONE, light grey, mainly quartz, fine-grained, argillaceous, micaceous, pyritic, with shaly and carbonaceous partings.

1'6" LIMESTONE, greyish brown, microcrystalline, slightly argillaceous and carbonaceous.

5'0" SILTSTONE, light grey, pyritic, micaceous, laminated with SHALE and fine-grained SANDSTONE.

Core 28 2082-2101 Recovery 19'0"

5'0" SILTSTONE, light grey, pyritic, micaceous, laminated with SHALE and fine-grained SANDSTONE.

1'0" SANDSTONE, light grey, fine-grained, mainly quartz, argillaceous, micaceous, with pyrite nodules, slightly oil stained, friable.

2'0" SILTSTONE, as above.

4'6" SANDSTONE, light grey to brown, fine-grained, mainly quartz, argillaceous, slightly glauconitic towards the bottom, with pyrite nodules, oil stained, friable.

2'6" SHALE, dark grey to black, micaceous, with pyrite nodules, silty laminae and sand lenses, fissile.

4'0" SANDSTONE, light brown, fine-grained, mainly quartz, argillaceous, carbonaceous and shaly partings, with pyrite nodules, oil stained, friable.

Core 29 2101-2107 Recovery 7'0"

6'0" SANDSTONE, light brown, fine-grained, very argillaceous, silty and carbonaceous partings, heavily impregnated with oil, friable, grades to SILTSTONE with carbonaceous partings towards bottom.

1'0" SHALE, bluish green at top turning pinkish towards bottom, waxy, abundant pyrite nodules, slickensides common.

APPENDIX B

GLOSSARY OF DESCRIPTIVE TERMINOLOGY

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Acolpate: Pollen without colpi i.e. equatorial longitudinal furrows or apertures.

Alete: Spores without laesurae i.e. proximal triradiate or single longitudinal aperture.

Alveolate: Pitted with small cavities.

Apical archeopyle: An opening in the fossil dinoflagellates formed by the loss of entire apical series of plates. Often it is indicated as a rupture along the line between the apical and precingular series of plates.

Apiculae: Small conical protuberances.

Arcuate lamellae: Membranous lamellae which run parallel to the equator in an arc joining the outer extremity of the trilete mark.

Arcuate ridges (= curvaturae): Ridges which run parallel to the equator in an arc joining the outer extremity of the trilete mark. Outer limits of the contact faces are usually marked by these ridges.

Auricle: Process shaped like lower lobe of the ear.

Baculae: Rod-like projections with or without modified tips.

Baculate: Ornamented with baculae.

Bisaccate: Pollen grains with two ectexinous protuberances or bladders on either side of the central body.

Bladders: (= sacci or vesicles): Ektexinous protuberances that stand apart from the central body e.g. gymnospermous pollen grains.

Bosses: Small knob-like protuberances.

Capilli: Free hair-like appendages.

Canaliculate: Ornamented with parallel or concentric narrow grooves.

Central body: Central portion of a cingulate or zonate spore, or saccate pollen.

Cicatricose: Ornamented with arcuate or straight parallel ridges and grooves. Ridges may often branch.

Cingulum: A thickened equatorial rim attached to a central body, the point of attachment being quite narrow and the rim and central body being in the same equatorial plane.

Cingulate: A spore with cingulum.

Clavate: Rod-shaped processes with expanded tips.

Colpi: Longitudinal apertures or furrows on the equator of a pollen grain. Germinal furrows serving as a place of emission of the pollen tube among the angiosperms.

Commissure: The line of dehiscence on trilete or monolete rays of spores. It refers only to the trace of the slit and excludes lips, margo or contact areas.

Coni: Small cone-shaped protuberances.

Contact faces: Following the simultaneous divisions of the nucleus of the spore mother cell, spores are in contact with each other along the contact faces. Each spore has three contact faces. The contact faces meet at the proximal pole of the spore. They are laterally separated by the trilete mark and distally limited by curved lines or ridges called arcuate ridges or *curvaturae*.

Coronate: When the margin of the zone is radially ruptured and looks like corona.

Distal: That part of the pollen grain or spore which faces outwards in the tetrad.

Distal face or surface: All area in the distal hemisphere.

Distal pole: Centre of the distal surface.

Distal sulcus or furrow (= leptoma or tenuitas): Longitudinal furrow on the distal surface of a pollen grain. It is a germinal furrow serving as a place of emission of the pollen tube among the gymnosperms and some monocotyledons. It is not a real aperture but only a thin aperturoid area, functioning as a germination area gradually merging into the surrounding exine.

Echinate: Ornamentation consisting of long spines with pointed tips and broadening base.

Ektexine (= exoexine or sexine): The outer layer of exine.

Endexine (= intexine or nexine): The inner layer of exine.

Equator: A line separating the distal from the proximal hemisphere in spores and pollen.

Equatorial outline: Outline as seen in polar view.

Exine: The main outer resistant layer of sporoderm.

Fimbriae: Hair-like processes.

Foveolate: With pits up to 2 microns in diameter, or if larger, too widely separated to form a reticulum.

Foveo-reticulate: With pits large enough and close enough together to form a reticulum, but the intervening walls are very wide. It is an intermediate condition between foveolate and reticulate.

Germinal furrow: See distal sulcus or furrow.

Granulate: Ornamented with circular projections whose height is less than their basal diameter. Usually less than 1/20 the size of the spore in measurement; terms infra- or sub-granulate are used for comparatively smaller sized granules.

Inter-radial (= inter-apical): The area between the adjacent commissures and the side of a trilete spore.

Kyrtome (= Torus): Formed by an abruptly convex exine area surrounding the laesurae which is reduced to three arcuate folds in the proximal inter-radial regions on compressed spores.

Laesurae: Triradiate (trilete) or single (monolete) tetrad scar. It also includes the commissure, lips, margo etc. when present.

Laevigate (= psilate): Smooth.

Lumen: Spaces between the muri of a reticulum.

Marginal crest: Thickened edge of the proximal cap on the central body of coniferous pollen.

Margo: A distinct area surrounding the commissures or apertures distinguished by the differences in the thickness of endexine or ectexine or by the absence or reduction of exine sculpture in that area.

Monolete: A proximal single slit-like laesura on spores.

Monoporate: Having a single germ-pore in the exine.

Monosulcate: Pollen having a single longitudinal distal sulcus or furrow e.g. cycads.

Muri: Ridges separating the lumina of a reticulum.

Neck segments: Leaf-like segments surrounding the trilete mark and constituting a neck-like projection on the proximal side e.g. Arcellites, Balmisporites etc.

- Patella:** Thickened ektexine layer confined to the equatorial and distal surfaces of the spore body.
- Perine (= perispore):** The outermost layer, outside the exine, in certain spores.
- Pole:** The centre of either the distal or proximal surface.
- Proximal:** Part of the spore facing toward the centre of the tetrad.
- Proximal pole:** Centre of the proximal surface.
- Proximal face or surface:** All area in the proximal hemisphere.
- Proximal cap:** The proximal part of the central body of a coniferous pollen which has thicker exine than the distal part.
- Punctate:** Ornamentation composed of very minute granules.
- Raised lips (= labra):** Raised exinal margins of trilete or monolete commissures.
- Reticulate:** Ornamentation consisting of a network of ridges (muri) surrounding regular or irregular depressions (lumina).
- Ribs (= ridges):** Elongate more or less parallel-sided raised ektexinous areas separated by furrows. These include both hollow inflated structures (taeniae) and solid bands (lirae).
- Rugulae:** Long, narrow and raised wrinkles irregularly distributed on the spore surface.
- Rugulate:** Ornamented with rugulae.
- Scabrate:** Flecked; with minute pits or elevations less than 1 micron in size.
- Sulcus:** See distal sulcus or furrow.
- Sculptine:** That part of the ektexine which is involved in ornamentation or appendages. It refers to the sculptured ektexine.
- Trilete:** Triradiate laesurae. Germinal area on the proximal side of spores among the ferns.
- Triradiate lamellae (= tecta):** Raised membraneous lamellae on the trilete mark.
- Triradiate ridges:** Raised ridges on which the trilete laesurae are present.
- Velum:** Membraneous covering.

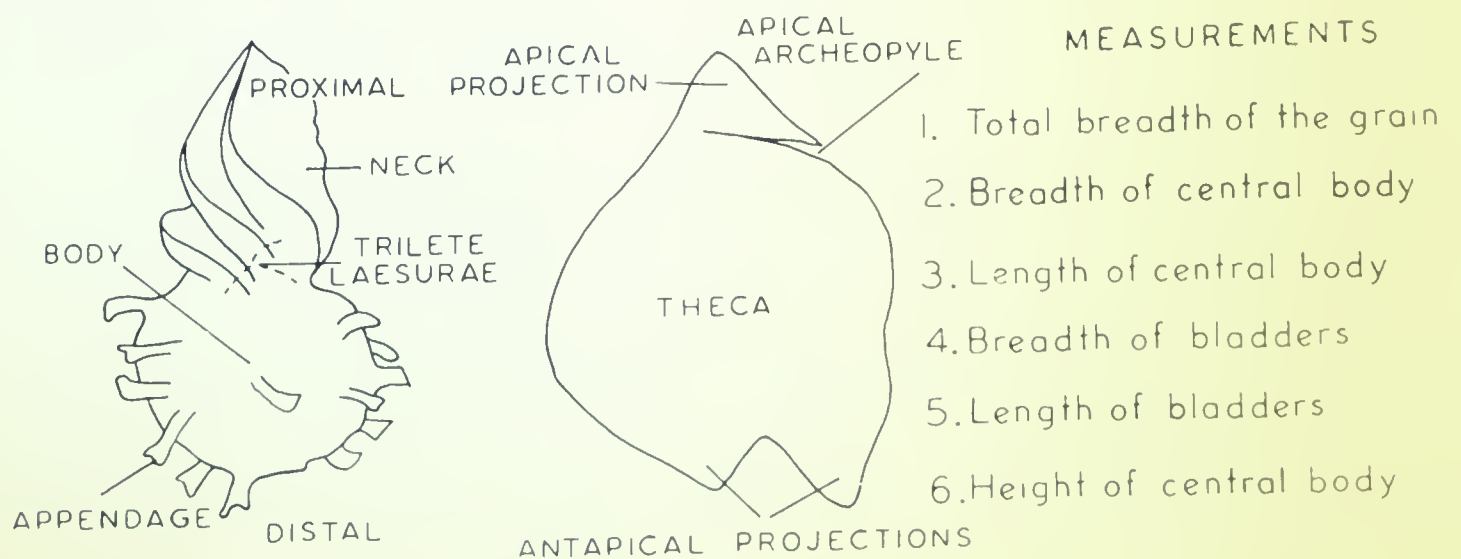
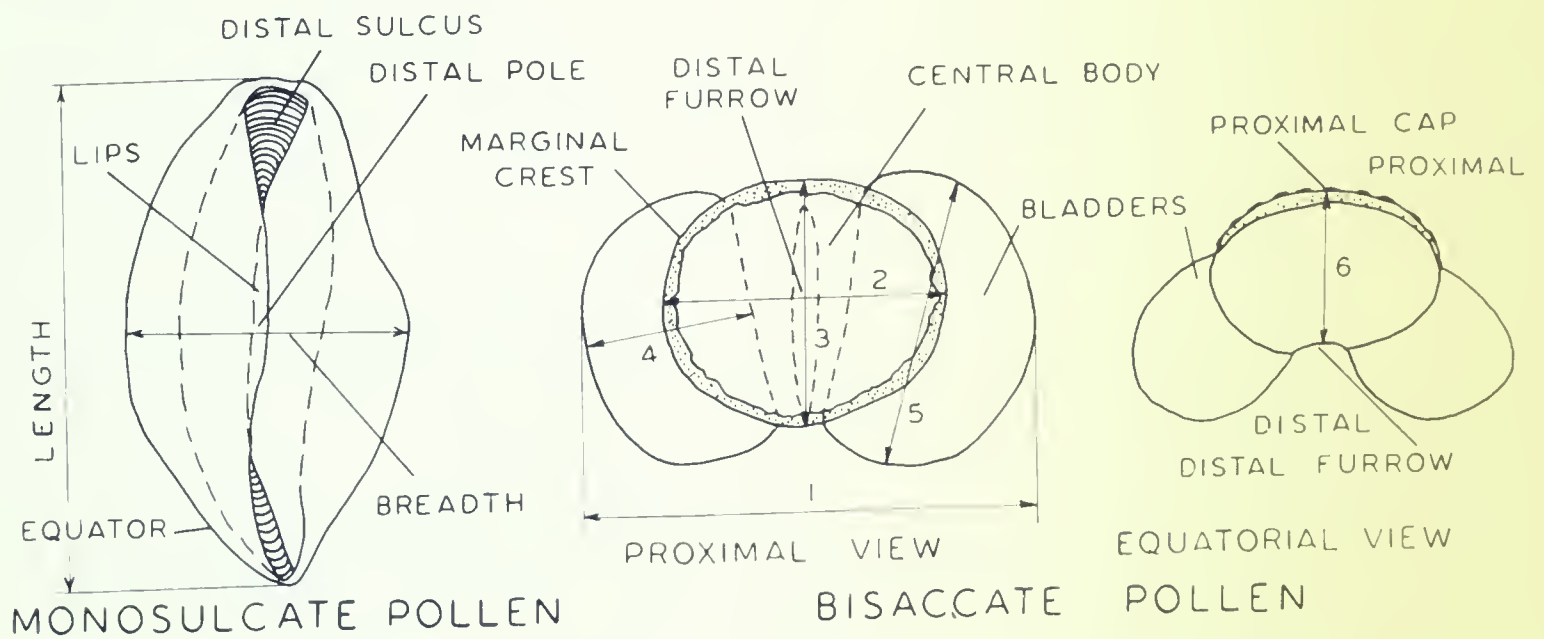
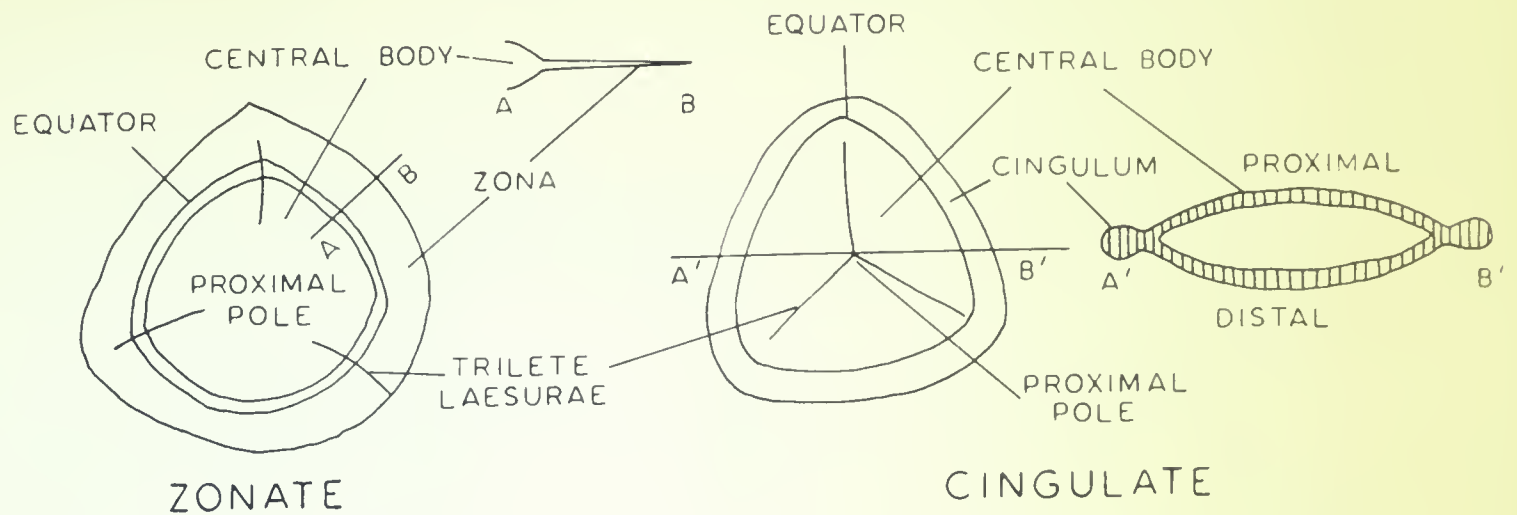
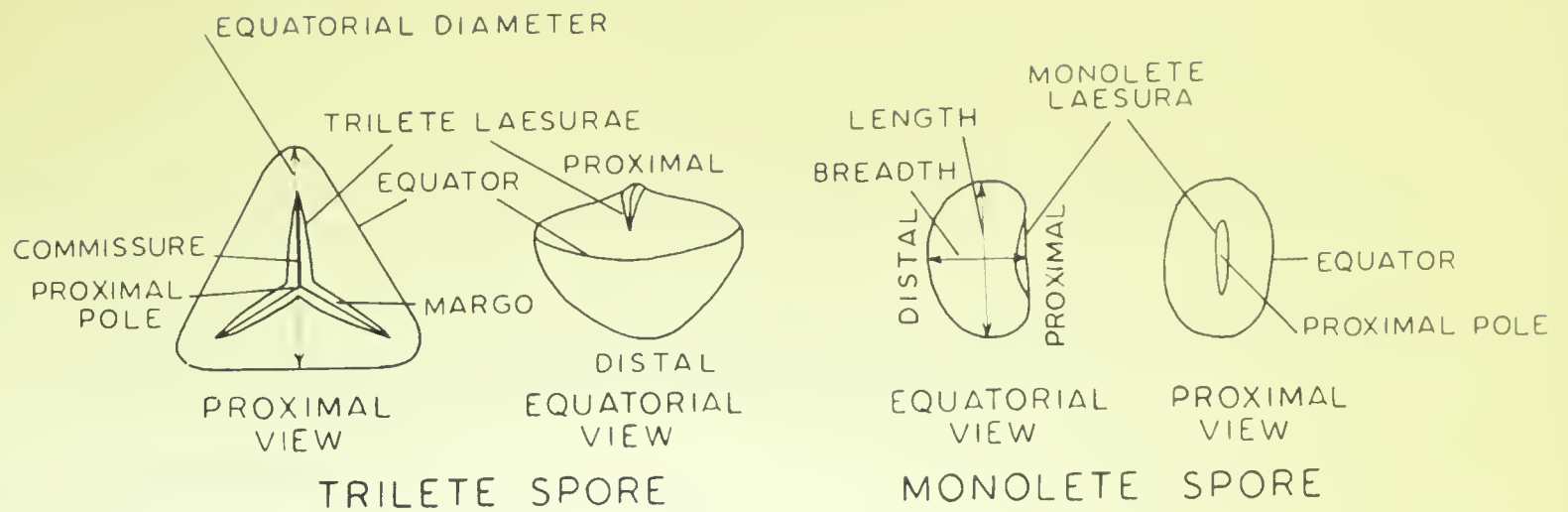


FIGURE 14. SCHEMATIC DRAWINGS SHOWING THE DIMENSIONS MEASURED AND ILLUSTRATING THE MORPHOLOGY OF THE SPORES AND POLLEN GRAINS.

Verrucose: Ornamented with wart-like protuberances. Warts slightly irregular, flat topped. Coarser than granulate texture.

Zona: A hyaline, thin flange, formed by the extension and fusion of the proximal and distal ectexine, around the equator of the spore.

Zonate: A spore with zona.

EXPLANATION OF PLATE 1

All specimens are illustrated at a magnification of X 500 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

Figure 1: Sphagnumsporites antiquasporites (Wilson and Webster) Pocock;
 proximal view, 20.4 microns, W1781-1791 (Grand Rapids Formation);
 known range: Upper Jurassic to Tertiary. (p. 107)

Figure 2: Sphagnumsporites psilatus (Ross) Couper; proximal view, 33
 microns, W1921-1931 (Grand Rapids Formation); known range:
 Jurassic to Cretaceous. (p. 108)

Figures 3,4: Lycopodiumsporites austroclavatidites (Cookson) Pocock;
 3 - proximal view, 35 microns, W1781-1791 (Grand Rapids
 Formation); 4 - distal view, 36 microns, W1791-1801 (Grand
 Rapids Formation); known range: Jurassic to Lower Cretaceous . (p. 109)

Figures 5,6: Lycopodiumsporites cerniidites (Ross) Delcourt and
 Sprumont; 5 - proximal view, 50 microns, F2442-2451 (Grand
 Rapids Formation); 6 - distal view, 46 microns, W1921-1931
 (Grand Rapids Formation); known range: Jurassic to Cretaceous . (p. 110)

Figures 7-10: Lycopodiumsporites marginatus n.sp.; 7 - proximal
 view, 51 microns, F3028-3037 (Ellerslie Member); 8 - (holotype)
 proximal view, 60 microns, F3084-3093 (Ellerslie Member);
 9 - (holotype) X 1024 proximal view; 10 - (holotype) X 1024 distal
 view; known range: Barremian? to Middle Albian (p. 111)

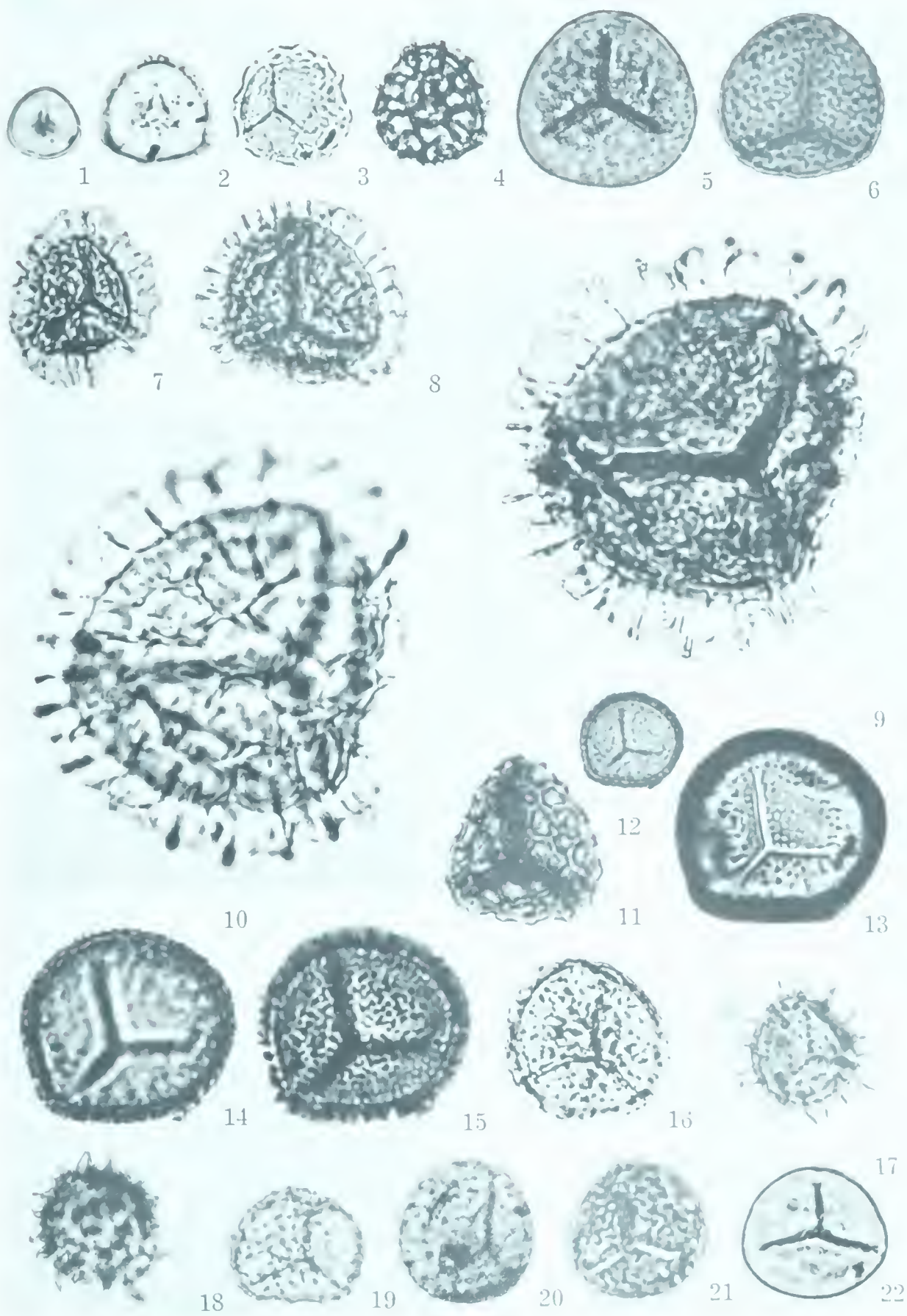
Figure 11: Lycopodiumsporites sp.A; distal view, 48 microns, W1781-
 1791 (Grand Rapids Formation); known range: Barremian? to
 Middle Albian. (p. 112)

Figures 12-15: Lycospora sp.; 12 - mid-focus, 30 microns, F2923-
 2932 (Wabiskaw Member); 13 - same specimen X 1024 proximal
 view; 14 - same specimen X 1024 mid-focus; 15 - same specimen
 X 1024 distal view; known range: Middle Albian (p. 113)

Figure 16: Lycospora cretacea Pocock; proximal view, 59 microns, W1781-
 1791 (Grand Rapids Formation); known range: Lower Cretaceous. (p. 114)

EXPLANATION OF PLATE 1 (cont'd)

- Figures 17, 18: Acanthotriletes varispinosus Pocock; 17 - proximal view, 32 microns (excluding spines), W1816-1826 (Grand Rapids Formation); 18 - distal view, 33 microns (excluding spines), N3850-3860 (Ellerslie Member); known range: Lower Cretaceous. (p. 115)
- Figure 19: Acanthotriletes levidensis Balme; proximal view, 38 microns, N3768-3778 (Ellerslie Member); known range: Lower Cretaceous (p. 116)
- Figure 20: Osmundacidites wellmanii Couper; proximal view, 40 microns, W1826-1836 (Grand Rapids Formation); known range: Jurassic to Lower Cretaceous. (p. 117)
- Figure 21: Rugulatisporites sp.; proximal view, 40 microns, F3075-3084 (Ellerslie Member); known range: Barremian? to Aptian . . (p. 118)
- Figure 22: Todisporites minor Couper; proximal view, 40 microns, F2607-2616 (Grand Rapids Formation); known range: Middle Jurassic to Lower Cretaceous (p. 119)



EXPLANATION OF PLATE 2

All specimens are illustrated at a magnification of X 500 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

Figure 1: Appendicisporites tricornitatus Weyland and Greifeld; distal view,
 47 microns; N3706-3716 (Ellerslie Member); known range:
 Cretaceous (p. 120)

Figures 2, 3: Appendicisporites crickmayii Pocock; 2 - proximal view,
 43 microns, N3850-3860 (Ellerslie Member); 3 - distal view,
 47 microns, N3850-3860 (Ellerslie Member); known range:
 Barremian? to Middle Albian (p. 121)

Figure 4: Appendicisporites jansonii Pocock; proximal view, 56 microns,
 F3213-3222 (Deville Member); known range: Barremian? to Aptian (p. 122)

Figures 5-7: Appendicisporites erdtmanii Pocock; 5 - proximal view,
 53 microns, W1781-1791 (Grand Rapids Formation); 6 - same
 specimen, X 1024 proximal view; 7 - same specimen, X 1024
 distal view; known range: Barremian? to Middle Albian (p. 123)

Figures 8-10: Appendicisporites cooksonii (Balme) Pocock; 8 - distal
 view, 48 microns, F3213-3222 (Deville Member); 9 - same
 specimen, X 1024 proximal view; 10 - same specimen, X 1024
 distal view; known range: Callovian to Albian (p. 124)

Figures 11, 12: Appendicisporites crimensis (Bolkhovitina) Pocock; 11 -
 mid-focus, 39 microns, W1816-1826 (Grand Rapids Formation);
 12 - same specimen, X 1024 proximal view; known range:
 Hauterivian to Albian (p. 126)

Figure 13: Appendicisporites cf. A. pschekhaensis (Bolkhovitina)
 Pocock; mid-focus, 59 microns, W1781-1791 (Grand Rapids
 Formation); known range: Neocomian to Middle Albian (p. 127)

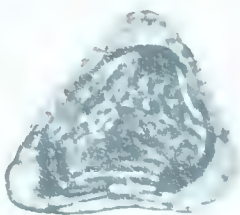
Figure 14: Appendicisporites sp.; mid-focus, 84 microns, F3213-3222
 (Deville Member); known range: Barremian? (p. 129)



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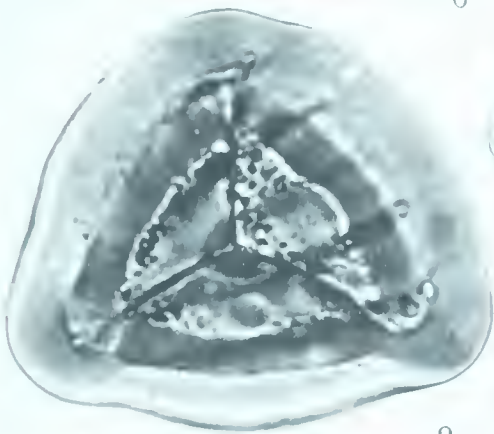
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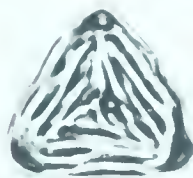
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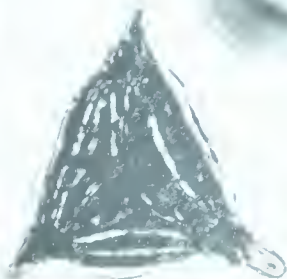
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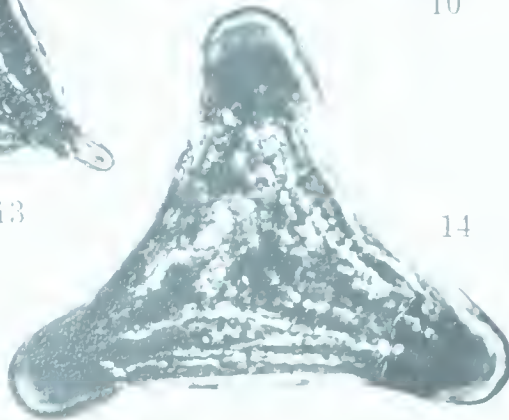
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EXPLANATION OF PLATE 3

All specimens are illustrated at a magnification of X 500 unless otherwise stated

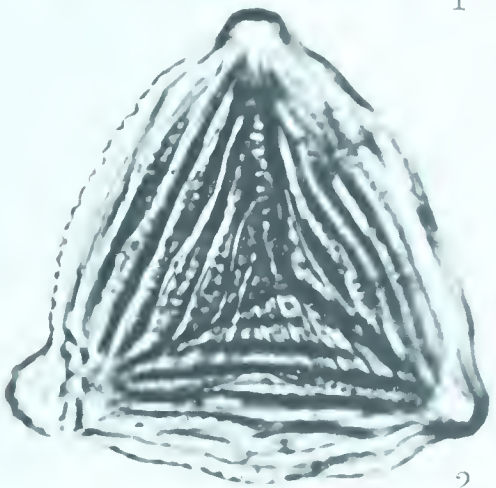
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F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
Depth position in well is in feet.

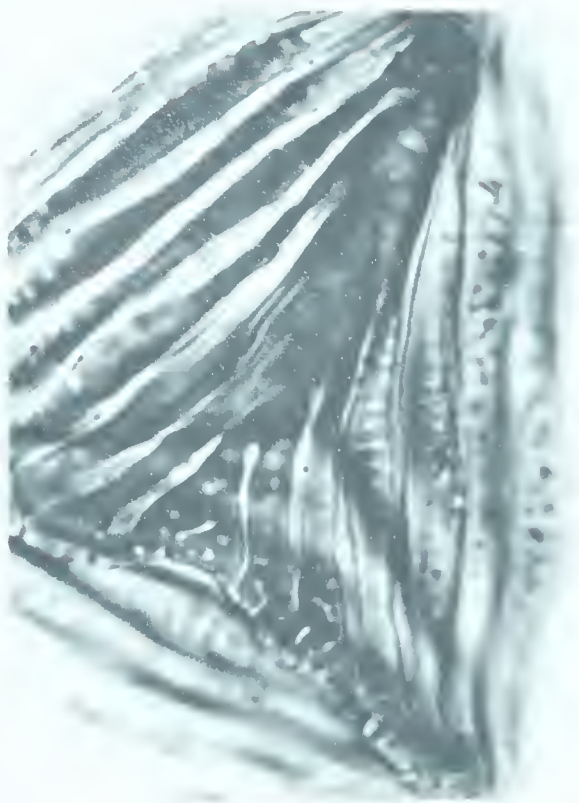
Figures 1-6: Appendicisporites trichacanthus (Maljavkina) var. dissectus
(Markova) n. comb.; 1 - proximal view, 97 microns, F2932-2938
(Wabiskaw Member); 2 - same specimen, distal view; 3 - same
specimen, X 1024 distal rib pattern; 4 - 6 - same specimen,
X 1024 ornamentation on ribs; known range: Albian to Cenomanian (p. 129)



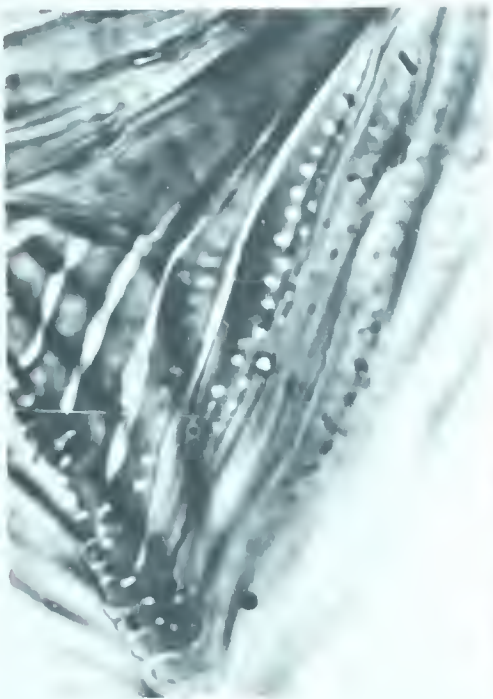
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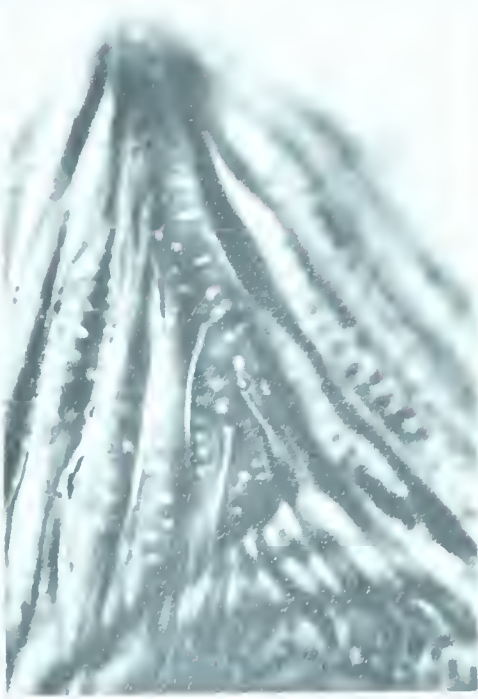
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EXPLANATION OF PLATE 4

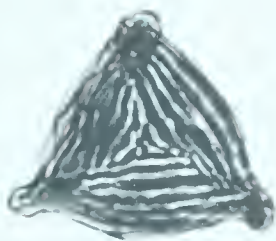
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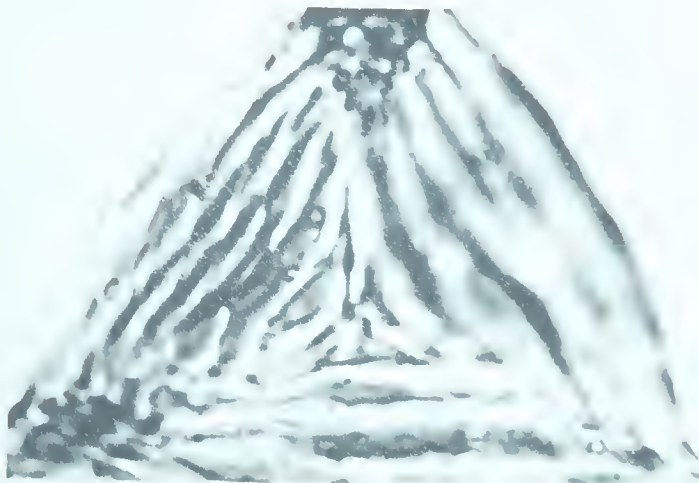
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 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

Figures 1-3: Appendicisporites cf. Anemia trichacantha (Maljavkina) Markova;
 1-mid-focus, 50 microns, F2905-2914 (Wabiskaw Member); 2 - same
 specimen X 1575 proximal view; 3 - same specimen X 1575 distal rib
 pattern; known range: Aptian to Cenomanian. (p. 131)

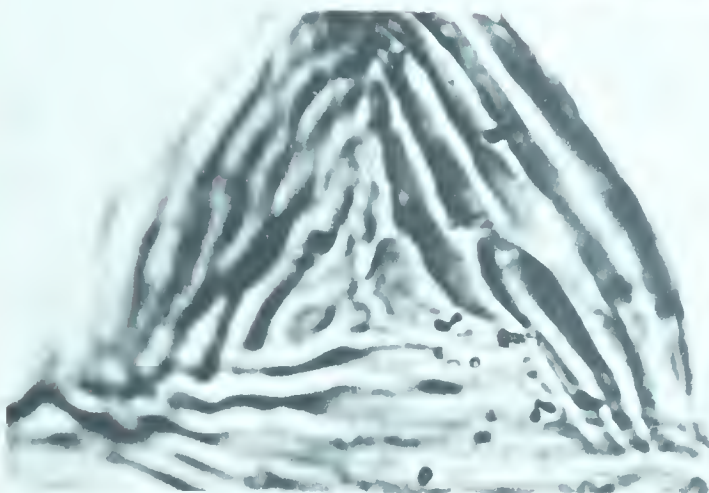
Figures 4-6: Appendicisporites unicus (Markova) n. comb.; 4-mid-focus,
 38 microns (excluding appendices), F2607-2616 (Grand Rapids
 Formation); 5 - same specimen X 1024 proximal view; 6 - same
 specimen X 1024 distal view; known range: Albian to Cenomanian (p. 133)



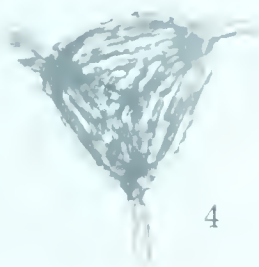
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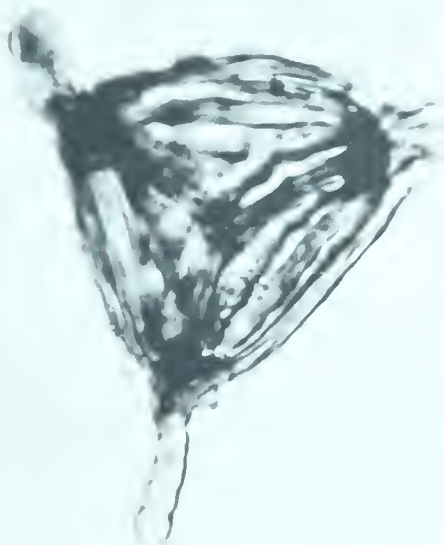
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EXPLANATION OF PLATE 5

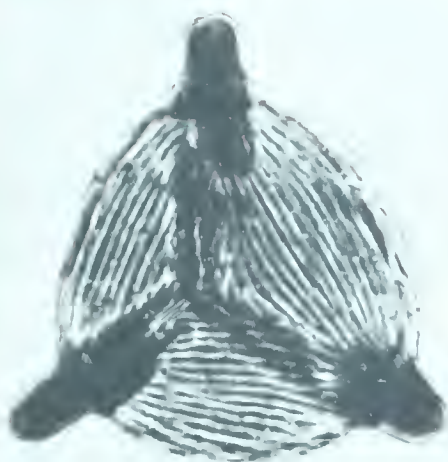
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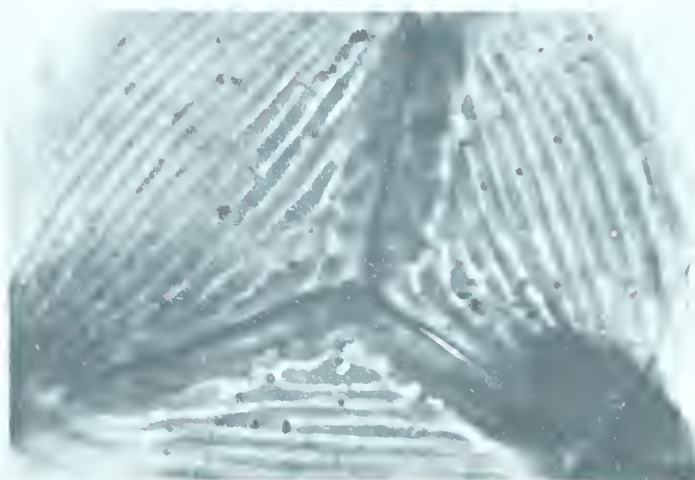
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 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

Figures 1-5: Appendicisporites bifurcatus n. sp.; 1 - (holotype) mid-focus, 94 microns, F2842-2851 (Clearwater Formation, Shale Member); 2 - (holotype) X 1024 proximal rib pattern; 3 - mid-focus, 93 microns, W1911-1921 (Grand Rapids Formation); 4 - (holotype) X 1024 bifurcation of appendices; 5 - (holotype) X 1024 distal rib pattern; known range: Middle Albian. (p. 134)

Figures 6-9: Appendicisporites perplexus n. sp.; 6 - (holotype) distal view, 44.2 microns, F2496-2505 (Grand Rapids Formation); 7 - proximal view, 39 microns, F2842-2851 (Clearwater Formation, Shale Member); 8 - (holotype) X 1024 proximal view; 9 - (holotype) X 1024 distal view; known range: Middle Albian (p. 135)



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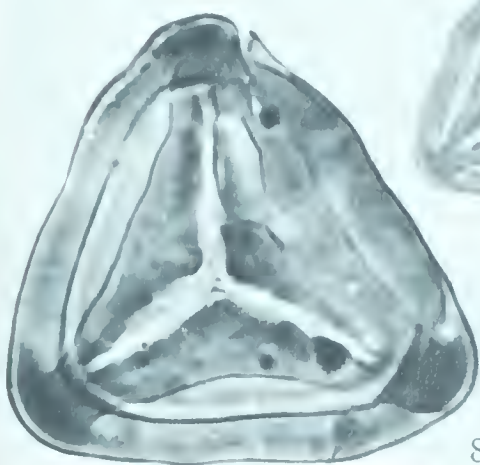
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EXPLANATION OF PLATE 6

All specimens are illustrated at a magnification of X 500 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

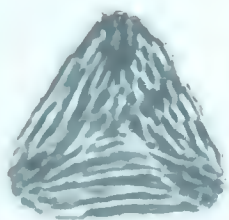
Figure 1: Cicatricosisporites doregensis Potonie and Gelletich, distal view,
 45 microns, W2095-2098 (Wabiskaw Member); known range:
 Purbeck to Tertiary (p. 138)

Figures 2-4: Cicatricosisporites dorsostriatus (Bolkhovitina) n. comb;
 2 - distal view, 52 microns, F2689-2699 (Clearwater Formation,
 Shale Member); 3 - same specimen X 1024 proximal view; 4 -
 same specimen X 1024 distal view; known range: Middle
 Jurassic to Albian (p. 139)

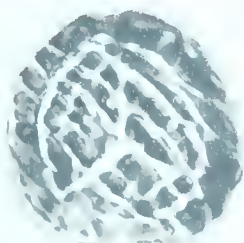
Figures 5-7: Cicatricosisporites perforatus (Baranov, Nemkova,
 Kondratiev) n. comb.; 5 - distal view, 54 microns, N3860-3870
 (Ellerslie Member); 6 - same specimen X 1024 proximal view;
 7 - same specimen X 1024 distal view; known range:
 Barremian? to Turonian. (p. 141)

Figure 8: Cicatricosisporites mediotriatus (Bolkhovitina) Pocock;
 mid-focus, 50 microns, N2686-2696 (Ellerslie Member);
 known range: Hauterivian to Turonian (p. 142)

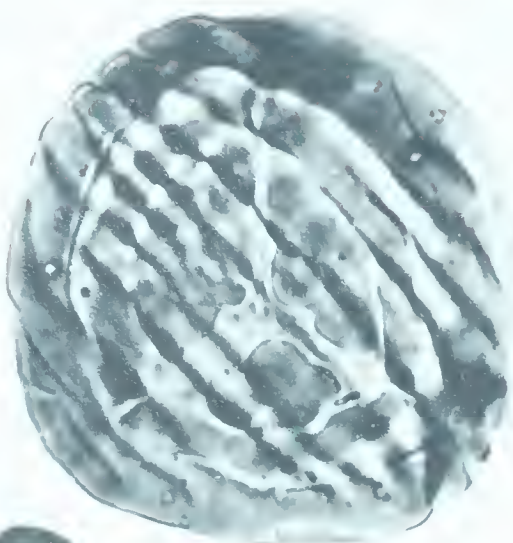
Figures 9-12: Cicatricosisporites orbiculatus n. sp.; 9 - (holotype)
 mid-focus, 34 microns, N3860-3870 (Ellerslie Member); 10 -
 (holotype) X 1024 proximal view; 11 - (holotype) X 1024 mid-
 focus; 12 - (holotype) X 1024 distal view; known range:
 Barremian? (p. 143)



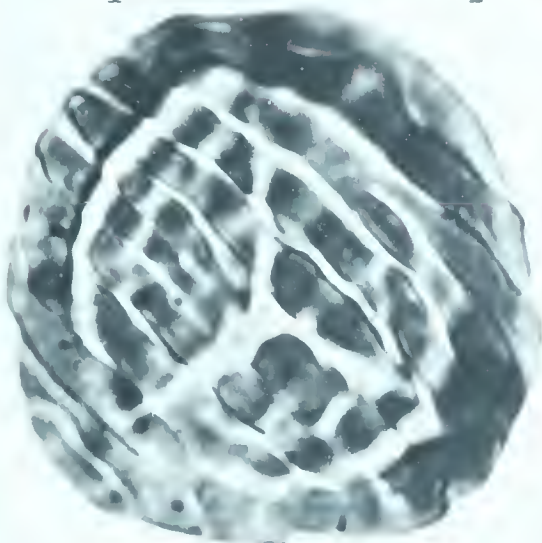
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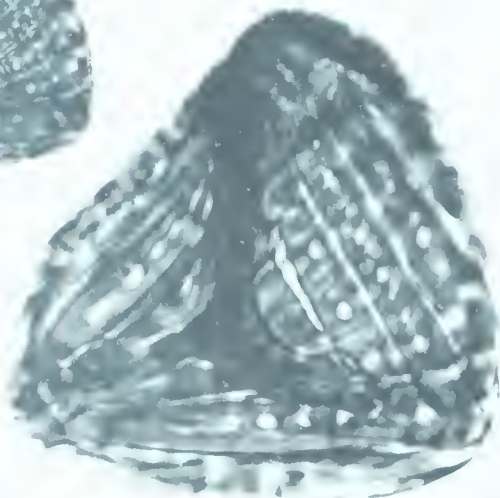
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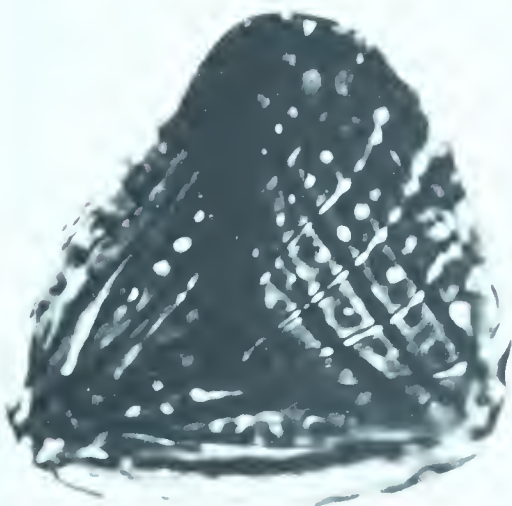
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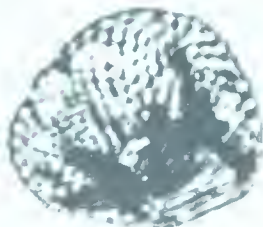
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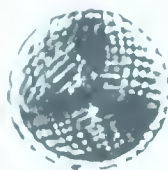
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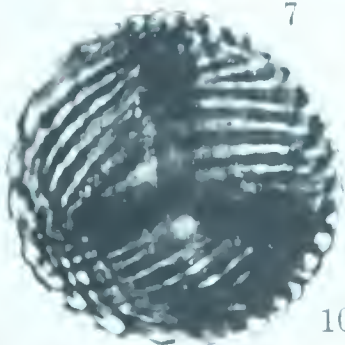
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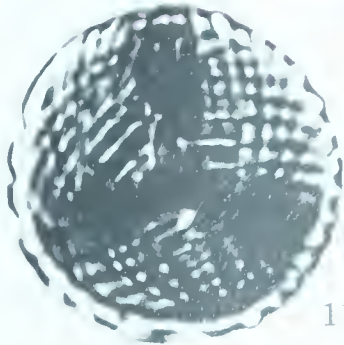
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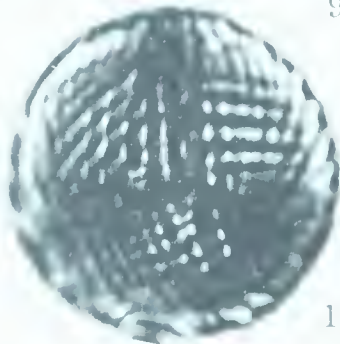
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EXPLANATION OF PLATE 7

All specimens are illustrated at a magnification of X 500 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

Figures 1-3: Cicatricosisporites sp. A; 1 - mid-focus, 60 microns, F2932-2938 (Wabiskaw Member), 2 - same specimen X 1024 proximal view; 3 - same specimen X 1024 distal view; known range: Middle Albian. (p. 144)

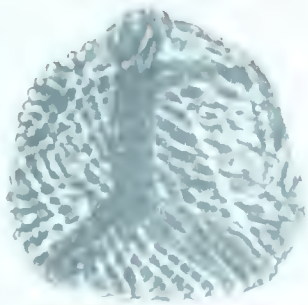
Figures 4-6: Cicatricosisporites sp. B; 4 - distal view, 46 microns, F2562-2571 (Grand Rapids Formation); 5 - same specimen X 1024 proximal view; 6 - same specimen X 1024 distal view; known range: Middle Albian (p. 144)

Figure 7: Chomotriletes almegrensis Pocock; mid-focus, 38 microns, F2598-2607 (Grand Rapids Formation); known range: Barremian? to Middle Albian (p. 146)

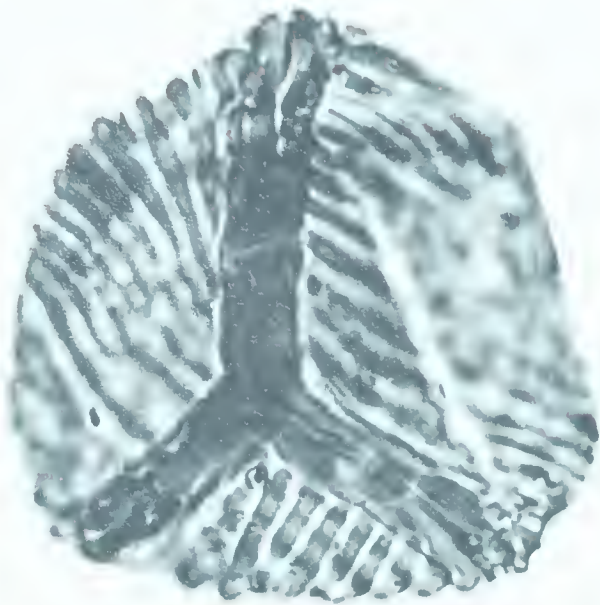
Figures 8, 9: Schizaeoisporites eocenicus (Selling) Potonie; 8 - equatorial view, 66 x 37 microns, F2833-2842 (Clearwater Formation, Shale Member); 9 - equatorial view, 65 x 38 microns, F2932-2938 (Wabiskaw Member); known range: Lower Cretaceous to Eocene (p. 148)

Figures 10, 11: Schizaeoisporites phaseolus Delcourt and Sprumont; 10 - equatorial view, 45 x 26 microns, W1781-1791 (Grand Rapids Formation); 11 - equatorial view, 50 x 30 microns, F2860-2869 (Clearwater Formation, Shale Member); known range: Lower Cretaceous (p. 149)

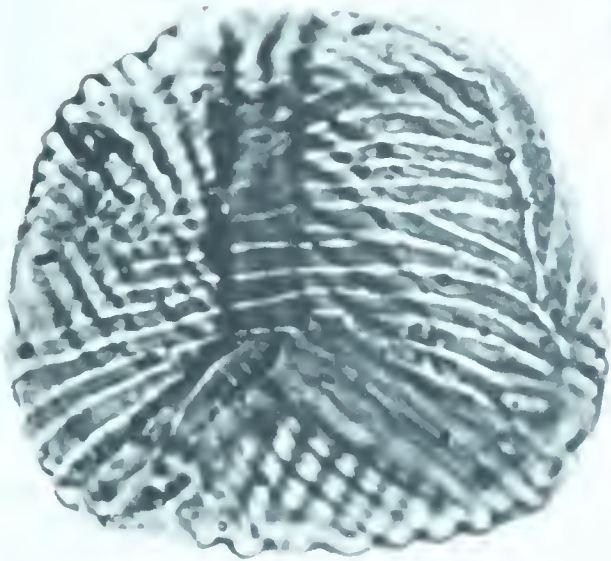
Figures 12, 13: Dictyotriletes pseudoreticulatus (Couper) Pocock; 12 - distal view, 52 microns, W1781-1791 (Grand Rapids Formation); 13 - equatorial view, 46 microns, N3726-3736 (Ellerslie Member); known range: Upper Jurassic to Lower Cretaceous (p. 150)



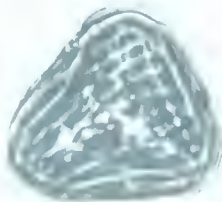
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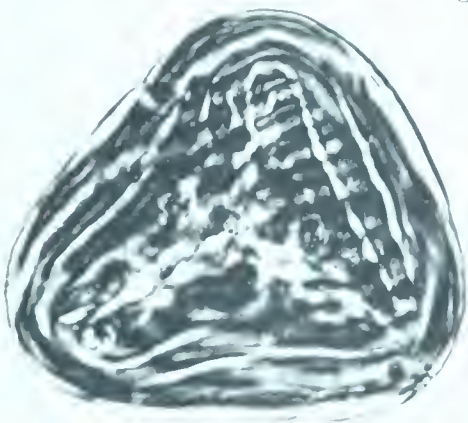
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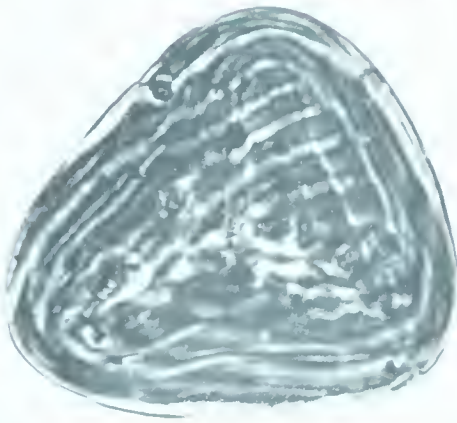
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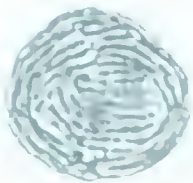
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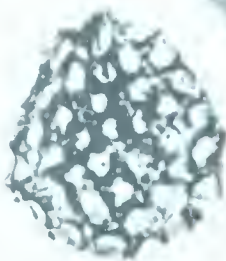
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EXPLANATION OF PLATE 8

All specimens are illustrated at a magnification of X 500 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

- Figure 1: Klukisporites sp.; distal view, 51 microns, W1781-1791 (Grand Rapids Formation); known range: Middle Albian (p. 152)
- Figure 2: Lygodioisporites sp. A; mid-focus, 65 microns, F2923-2932 (Wabiskaw Member); known range: Middle Albian (p. 154)
- Figure 3: Lygodioisporites sp. B; proximal view, 58 microns, F2451-2460 (Grand Rapids Formation); known range: Middle Albian (p. 154)
- Figure 4: Lygodiumsporites sp. A; proximal view, 60 microns, F3010-3019 (Ellerslie Member); known range: Barremian? to Middle Albian (p. 156)
- Figure 5: Lygodiumsporites sp. B; proximal view, 85 microns, W1816-1826 (Grand Rapids Formation); known range: Middle Albian (p. 158)
- Figures 6, 7: Neoraistrickia? sp.; 6 - proximal view, 42 microns, F3174-3179 (Ellerslie Member); 7 - same specimen X 1024 clavate spines; known range: Barremian? (p. 159)
- Figures 8, 9: Gleicheniidites senonicus Ross; 8 - proximal view, 32 microns, F2815-2824 (Clearwater Formation, Shale Member); 9 - proximal view, 29 microns, F2782-2785 (Clearwater Formation, Shale Member); known range: Jurassic to Cretaceous (p. 160)
- Figures 10, 11: Gleicheniidites cf. G. circinidites (Cookson) n. comb.; 10 - mid-focus, 27.5 microns, W1781-1791 (Grand Rapids Formation); 11 - same specimen showing diffraction pattern related with thickened zones; known range: Upper Jurassic to Lower Cretaceous and Eocene? (p. 161)
- Figure 12: Cyathidites australis Couper; proximal view, 50 microns, W1791-1801 (Grand Rapids Formation); known range: Jurassic to Lower Cretaceous (p. 162)

EXPLANATION OF PLATE 8 (cont'd)

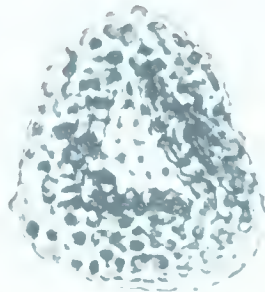
- Figure 13: Cyathidites minor Couper; mid-focus, 36 microns, W1816-1826
(Grand Rapids Formation); known range: Jurassic to Cretaceous (p. 163)
- Figures 14, 15: Trilobosporites hannonicus (Delcourt and Sprumont)
Potonie; 14 - proximal view, 64 microns, F3213-3222 (Deville
Member); 15 - proximal view, 70 microns, F3222-3231
(Deville Member); known range: Barremian? to Aptian? (p. 164)
- Figures 16-18: Trilobosporites apiverrucatus Couper; 16 - proximal
view, 63 microns, W2085-2095 (Wabiskaw Member); 17 -
proximal view, 54 microns, N3726-3736 (Ellerslie Member);
18 - mid-focus, 47 microns, F2905-2914 (Wabiskaw Member);
known range: Berriasian to Middle Albian (p. 165)
- Figures 19-20: Trilobosporites canadensis Pocock; 19 - proximal view,
64 microns, N3768-3778 (Ellerslie Member); 20 - proximal view,
52 microns, N3706-3716 (Ellerslie Member); known range:
Barremian? to Aptian (p. 166)



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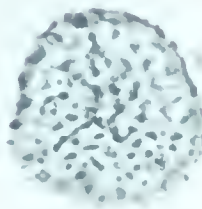
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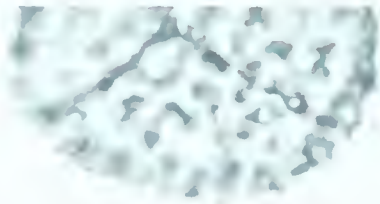
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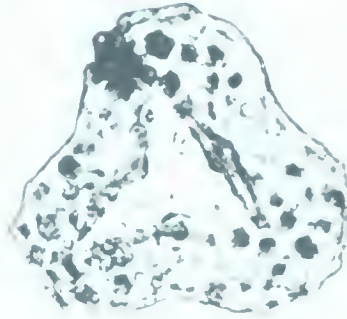
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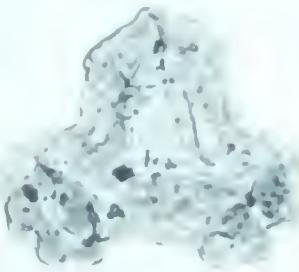
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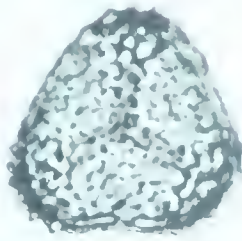
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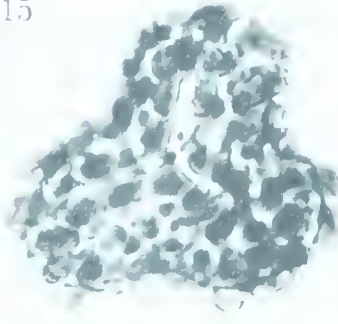
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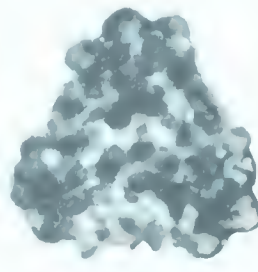
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EXPLANATION OF PLATE 9

All specimens are illustrated at a magnification of X 500 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

Figures 1,2: Trilobosporites trioreticulosus Cookson and Dettmann; 1 - proximal view, 64 microns, F2983-2992 (Calcareous Member); 2 - proximal view, 60 microns, F2932-2938 (Wabiskaw Member); known range: Barremian? to Albian (p. 168)

Figure 3: Trilobosporites minor Pocock; proximal view, 32 microns, W1816-1826 (Grand Rapids Formation); known range: Lower Cretaceous (p. 169)

Figure 4: Pilosisporites trichopapillosus (Thiergart) Delcourt and Sprumont; distal view, 62 microns (excluding spines), N3850-3860 (Ellerslie Member); known range: Purbeck to Middle Albian. (p. 169)

Figure 5: Pilosisporites verus Delcourt and Sprumont; proximal view 63 microns (excluding spines), N3768-3778 (Ellerslie Member); known range: Lower Cretaceous (p. 170)

Figures 6,7: Concavissimisporites punctatus (Delcourt and Sprumont) n. comb.; 6 - proximal view, 74 microns, F2815-2824 (Clearwater Formation, Shale Member); 7 - proximal view, 56 microns, W1781-1791 (Grand Rapids Formation); known range: Berriasian to Aptian (p. 172)

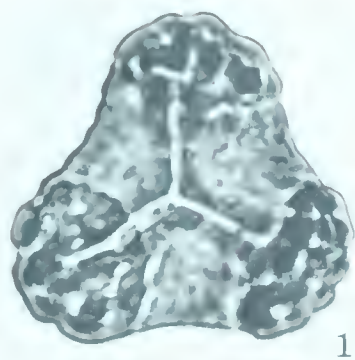
Figure 8: Concavissimisporites parkinii (Pocock) n. comb.; proximal view, 59 microns, N3850-3860 (Ellerslie Member); known range: Barremian? to Aptian (p. 175)

Figures 9-11: Concavissimisporites variverrucatus (Couper) n. comb.; 9 - proximal view, 56 microns, F3093-3102 (Ellerslie Member); 10 - distal view, 50 microns, N3686-3696 (Ellerslie Member); 11 - proximal view, 56 microns, F3093-3102 (Ellerslie Member); known range: Bajocian to Middle Albian (p. 176)

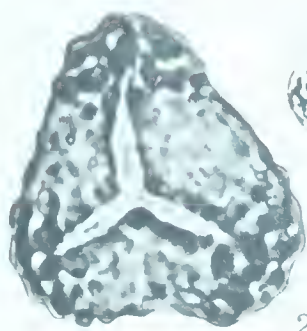
Figure 12: Concavissimisporites sp.; mid-focus, 44 microns, F3010-3019 (Ellerslie Member); known range: Barremian? to Aptian . . (p. 177)

EXPLANATION OF PLATE 9 (cont'd)

- Figures 13, 14: Deltoidospora hallii Miner; 13 - proximal view, 32 microns, N3768-3778 (Ellerslie Member); 14 - distal view, 30 microns, N3726-3736 (Ellerslie Member); known range: Mesozoic (p. 178)
- Figure 15: Deltoidospora psilostoma Rouse; mid-focus, 46 microns, N3716-3726 (Ellerslie Member); known range: Bathonian to Upper Cretaceous (p. 179)
- Figure 16: Deltoidospora junctum (Kara-Murza) n. comb.; proximal view, 30 microns, F2496-2505 (Grand Rapids Formation); known range: Upper Jurassic to Lower Cretaceous (p. 180)
- Figures 17-19: Hymenozonotriletes mesozoicus Pocock; 17 - proximal view, 62 microns, F3093-3102 (Ellerslie Member); 18 - distal view of same specimen; 19 - same specimen X 2500 distal spines; known range: Barremian? to Aptian (p. 182)



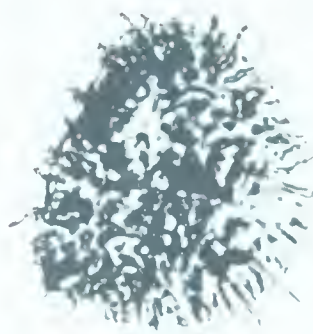
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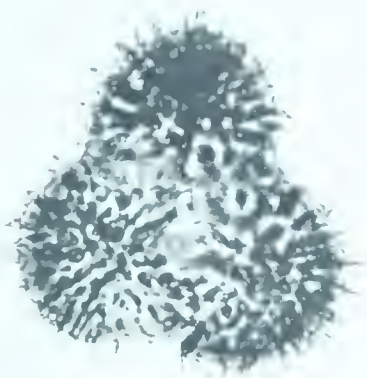
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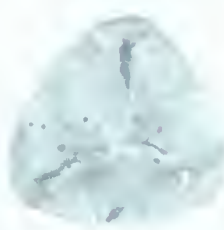
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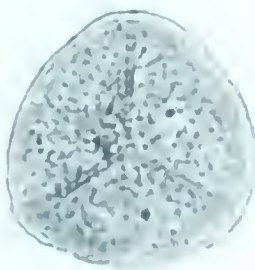
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EXPLANATION OF PLATE 10

All specimens are illustrated at a magnification of X 500 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);

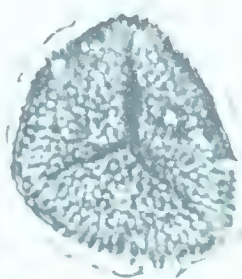
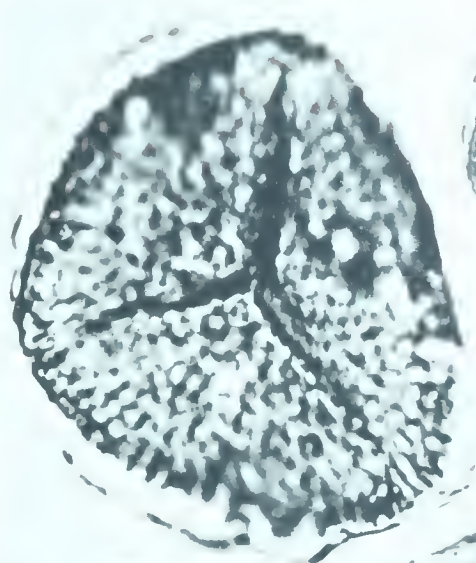
F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);

W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).

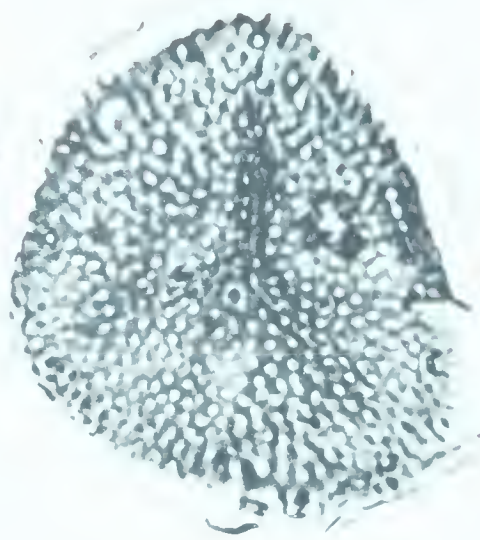
Depth position in well is in feet.

Figures 1-3: Hymenozonotriletes pseudoalveolatus (Couper) n. comb.; 1 - proximal view, 58 microns, W1921-1931 (Grand Rapids Formation); 2 - same specimen X 1024 proximal view; 3 - same specimen X 1024 distal view; known range: Bajocian to Middle Albian (p. 183)

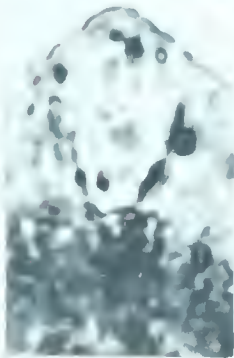
Figures 4-10: Couperisporites complexus (Couper) Pocock; 4 - proximal view, 88 microns, W1781-1791 (Grand Rapids Formation); 5 - distal view, 112 microns, W1911-1921 (Grand Rapids Formation); 6, 7 - X 1024 bifurcation of the commissures, W1911-1921 (Grand Rapids Formation); 8, 9, 10 - X 1024 distal ornamentation at low, mid and high focus respectively; 8, W1781-1791 (Grand Rapids Formation); 9, 10 - N3850-3860 (Ellerslie Member); known range: Barremian to Middle Albian (p. 184)



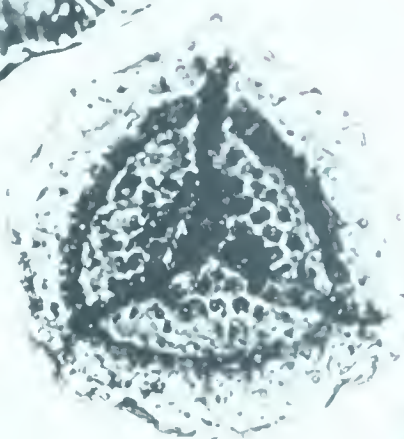
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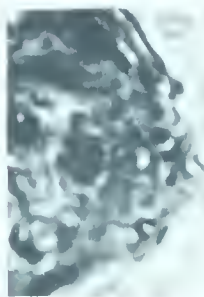
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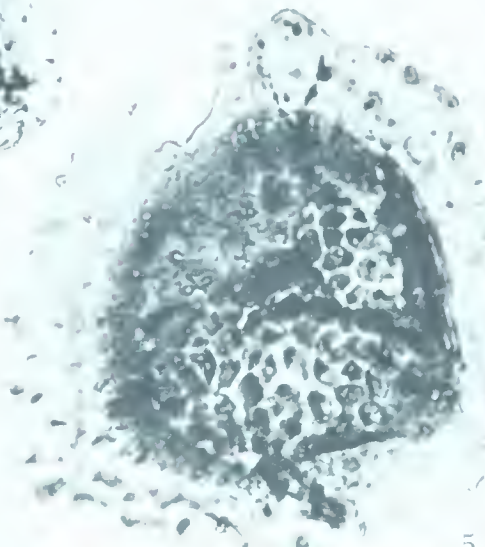
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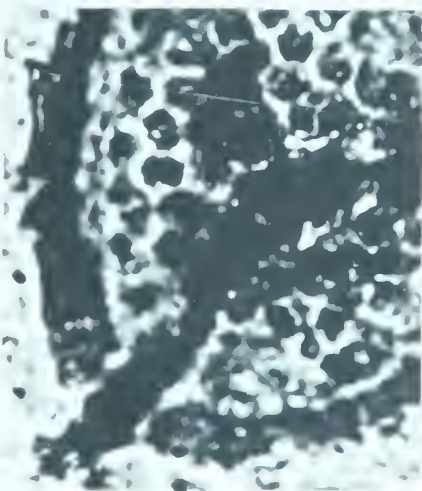
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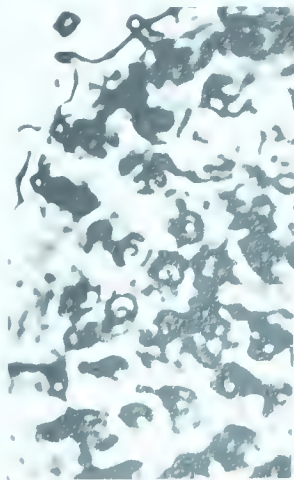
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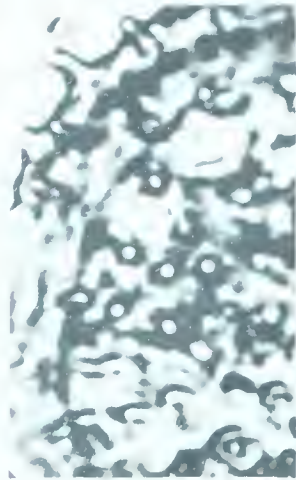
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EXPLANATION OF PLATE 11

All specimens are illustrated at a magnification of X 500 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

Figures 1-4: Staplinisporites caminus (Balme) Pocock; 1 - mid-focus, 36 microns, N3742-3743 (Ellerslie Member); 2 - distal view, 44 microns, F3213-3222 (Deville Member); 3 - same specimen X 1024 proximal view; 4 - same specimen X 1024 distal view; known range: Upper Jurassic to Lower Cretaceous (p. 186)

Figure 5: Taurocusporites segmentatus Stover; mid-focus, 46 microns, W1816-1826 (Grand Rapids Formation); known range: Lower Cretaceous (p. 188)

Figure 6: Taurocusporites reduncus (Bolkhovitina) Stover; mid-focus, 37 microns, W1816-1826 (Grand Rapids Formation); known range: Middle Jurassic to Upper Cretaceous. (p. 189)

Figures 7-11: Taurocusporites minor n. sp.; 7 - (holotype) distal view, 27 microns, F2923-2932 (Wabiskaw Member); 8 - (holotype) X 1024 proximal view; 9 - (holotype) X 1024 mid-focus; 10 - (holotype) X 1024 distal view; 11 - (holotype) X 2500 proximal view showing the extension of laesurae; known range: Barremian? to Middle Albian (p. 191)

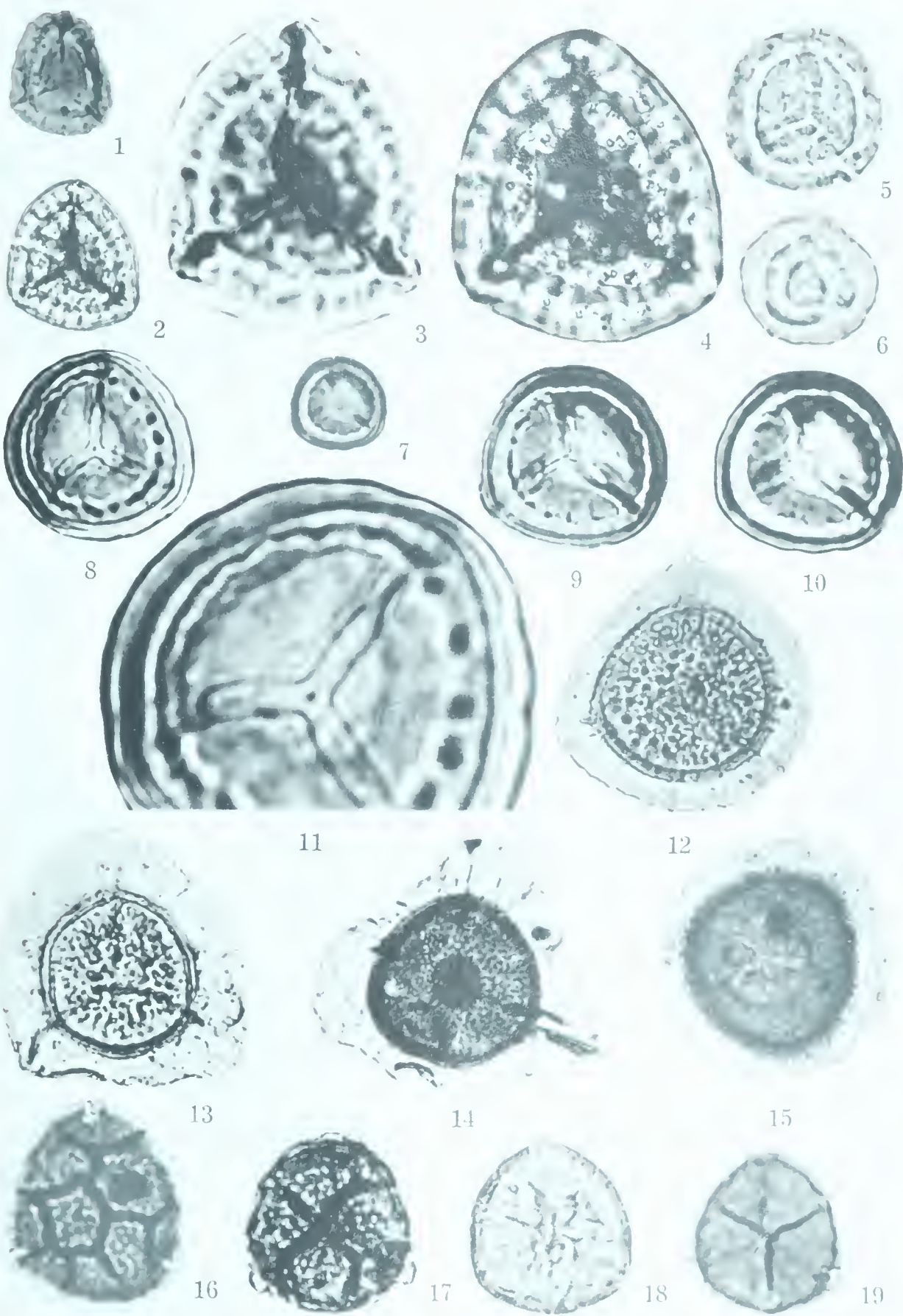
Figures 12, 13: Aequitriradites spinulosus (Cookson and Dettmann) Cookson and Dettmann; 12 - distal view, 74 microns, F3093-3102 (Ellerslie Member); 13 - proximal view, 78 microns, W1931-1941 (Grand Rapids Formation); known range: Cretaceous (p. 193)

Figures 14, 15: Aequitriradites variabilis Pocock; 14 - distal view showing exinous breakdown about the distal pole, 76 microns, F2896-2905 (Wabiskaw Member); 15 - distal view showing exinous breakdown about the distal pole, 72 microns, N3716-3726 (Ellerslie Member); known range: Barremian? to Middle Albian (p. 194)

Figures 16, 17: Rouseisporites reticulatus Pocock; 16 - distal view, 58 microns, F3037-3046 (Ellerslie Member); 17 - distal view, 51 microns, W1781-1791 (Grand Rapids Formation); known range: Barremian? to Albian (p. 196)

EXPLANATION OF PLATE 11 (cont'd)

- Figure 18: Rouseisporites laevigatus Pocock; distal view, 50 microns,
W1781-1791 (Grand Rapids Formation); known range: Barremian?
to Albian (p. 197)
- Figure 19: Rouseisporites triangularis Pocock; distal view, 46 microns,
F3174-3179 (Ellerslie Member); known range: Barremian? to
Albian (p. 198)



EXPLANATION OF PLATE 12

All specimens are illustrated at a magnification of X 500 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

Figures 1-3: Cooksonites variabilis Pocock; 1 - proximal view showing trilete
 laesurae, 70 microns, F3174-3179 (Ellerslie Member); 2 - distal view,
 72 microns, W1911-1921 (Grand Rapids Formation); 3 - same specimen
 X 1024 meshwork of polygonal plates on distal pole; known range:
 Barremian? to Aptian (p. 200)

Figures 4-7: Cooksonites reticulatus Pocock; 4 - mid-focus, 55 microns,
 F3010-3019 (Ellerslie Member); 5 - same specimen X 1024
 proximal view; 6 - same specimen X 1024 mid-focus; 7 - same
 specimen X 1024 distal view; known range: Barremian? to Aptian (p. 201)

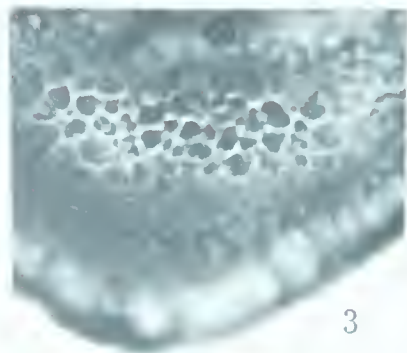
Figures 8-12: Januasporites spiniferus n. sp.; 8 - (holotype) proximal
 view, 57.4 microns, F2496-2505 (Grand Rapids Formation); 9 -
 proximal view, 62 microns, F2496-2505 (Grand Rapids Formation);
 10 - distal view of a spore without marginal exoexine, 45 microns,
 F2496-2505 (Grand Rapids Formation); 11 - proximal view, 58
 microns, F2496-2505 (Grand Rapids Formation); 12 - a tetrad,
 70 microns, F2496-2505 (Grand Rapids Formation); known range:
 Middle Albian (p. 202)



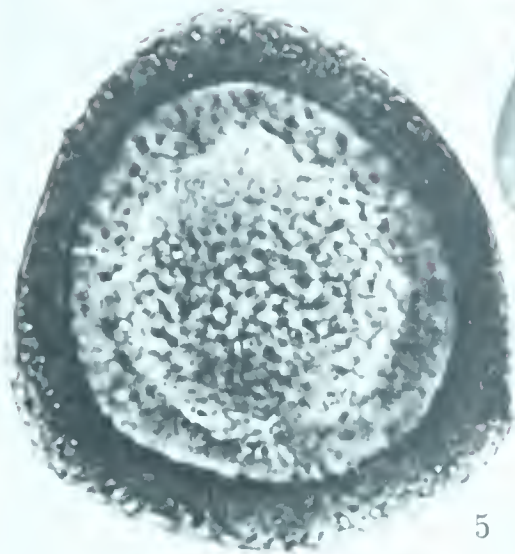
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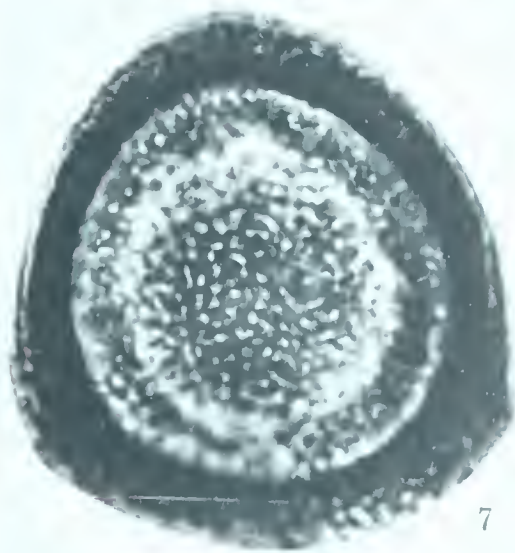
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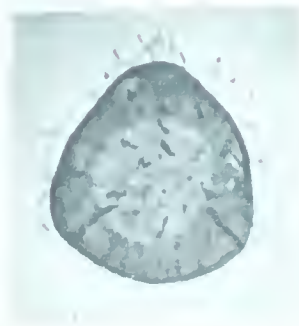
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EXPLANATION OF PLATE 13

All specimens are illustrated at a magnification of X 500 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

Figures 1,2: Verrucosisporites asymmetricus (Cookson and Dettmann) Pocock;
 1 - proximal view, 53 microns, W1781-1791 (Grand Rapids Formation);
 2 - proximal view, 43 microns, F3093-3102 (Ellerslie Member);
 known range: Barremian? to Albian (p. 204)

Figure 3: Verrucosisporites rotundus n. sp.; (holotype) proximal view,
 46 microns, N3742-3743 (Ellerslie Member); known range:
 Barremian? to Aptian (p. 205)

Figure 4: Verrucosisporites sp.; proximal view, 54 microns, F2860-
 2869 (Clearwater Formation, Shale Member); known range:
 Middle Albian (p. 206)

Figures 5-7: Microreticulatisporites uniformis n. sp.; 5 - (holotype)
 proximal view, 47 microns, W1781-1791 (Grand Rapids Formation);
 6 - proximal view, 45 microns, W1791-1801 (Grand Rapids
 Formation); 7 - mid-focus, 45 microns, W1826-1836 (Grand
 Rapids Formation); known range: Barremian? to Middle Albian (p. 207)

Figure 8: Granulatisporites sp.; mid-focus, 30 microns, F2782-2785
 (Clearwater Formation, Shale Member); known range: Barremian?
 to Middle Albian (p. 209)

Figures 9-11: Laevigatosporites ovatus Wilson and Webster; 9 - proximal
 view, 34 x 22 microns, N3768-3778 (Ellerslie Member); 10 -
 equatorial view, 34 x 22 microns, W1781-1791 (Grand Rapids
 Formation); 11 - sporangial mass, N3768-3778 (Ellerslie Member);
 known range: Upper Jurassic to Cretaceous (p. 210)

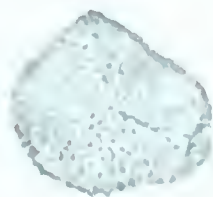
Figures 12,13: Dictyotosporites cf. D. speciosus Cookson and Dettmann;
 12 - mid-focus, 36 microns, F2938-2947 (Wabiskaw Member);
 13 - same specimen X 1024 proximal view; known range:
 Neocomian to Middle Albian (p. 211)

EXPLANATION OF PLATE 13 (cont'd)

- Figure 14: Schizosporis reticulatus Cookson and Dettmann; mid-focus,
105 microns, F2442-2451 (Grand Rapids Formation); known range:
Neocomian to Albian and Cenomanian? (p. 212)
- Figure 15: Schizosporis parvus Cookson and Dettmann; mid-focus,
90 x 60 microns, F2505-2514 (Grand Rapids Formation); known
range: Barremian? to Albian and Cenomanian? (p. 213)
- Figure 16: Schizosporis rugulatus Cookson and Dettmann; mid-focus,
78 microns, W1781-1791 (Grand Rapids Formation); known
range: Barremian? to Albian and Cenomanian? (p. 214)



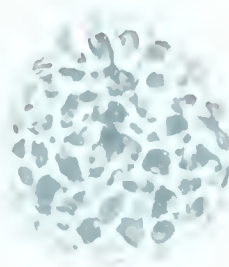
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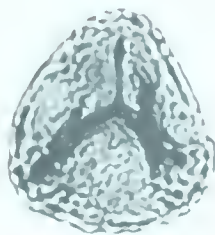
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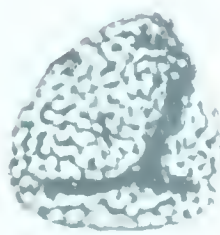
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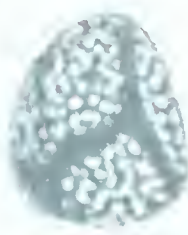
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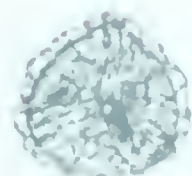
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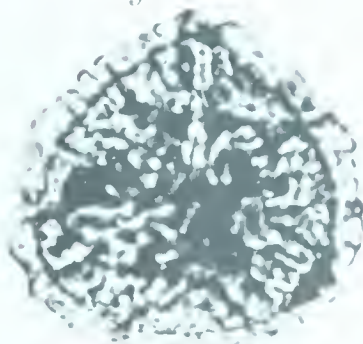
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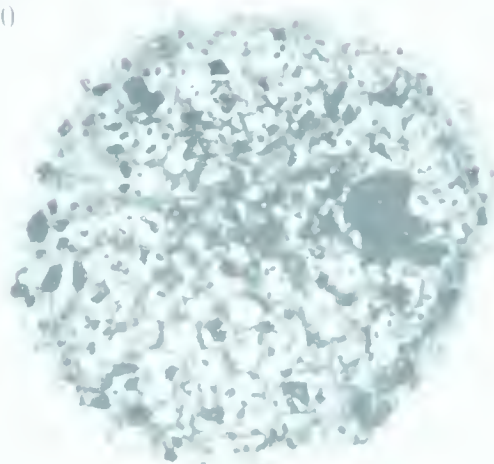
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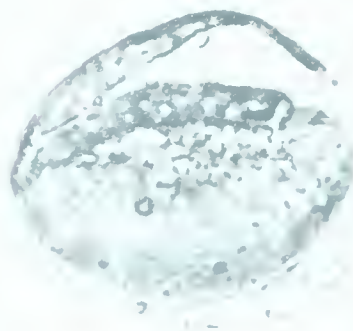
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16

EXPLANATION OF PLATE 14

All specimens are illustrated at a magnification of X 500 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

- Figure 1: Vitreisporites pallidus (Reissinger) Nilsson; distal view, 31 x 17 microns, W1816-1826 (Grand Rapids Formation); known range: Jurassic to Lower Cretaceous. (p. 215)
- Figure 2: Cycadopites fragilis n. sp.; (holotype) proximal view, 33 x 20 microns, W1816-1826 (Grand Rapids Formation); known range: Jurassic to Cretaceous. (p. 217)
- Figure 3: Cycadopites carpentieri (Delcourt and Sprumont) n. comb.; proximal view, 53 x 19 microns, F2905-2914 (Wabiskaw Member); known range: Middle Jurassic to Lower Cretaceous. (p. 218)
- Figures 4, 5: Cycadopites formosus n. sp.; 4 - (holotype) proximal view, 52 x 34 microns, F2689-2699 (Clearwater Formation, Shale Member); 5 - proximal view, 62 x 44 microns, W2040-2042.5 (Clearwater Formation, Shale Member); known range: Barremian? to Middle Albian. (p. 219)
- Figure 6: Cycadopites sp.; proximal view, 104 x 57 microns, F2932-2938 (Wabiskaw Member); known range: Barremian? to Middle Albian. (p. 220)
- Figure 7: Bennettiteaepollenites minimus n. sp.; (holotype) proximal view, 27.2 x 22 microns, W1951-1961 (Grand Rapids Formation); known range: Barremian? to Middle Albian (p. 221)
- Figure 8: Bennettiteaepollenites sp.; proximal view, 82 x 40 microns, N3850-3860 (Ellerslie Member); known range: Barremian? (p. 221)
- Figure 9: Perinopollenites elatoides Couper; mid-focus, 48 microns, F3174-3179 (Ellerslie Member); known range: Jurassic to Lower Cretaceous. (p. 223)
- Figure 10: Alisporites cf. A. microsaccus (Couper) Pocock; distal view, 80 x 84 microns, F3036-3046 (Ellerslie Member); known range: Upper Jurassic to Lower Cretaceous (p. 224)

EXPLANATION OF PLATE 14 (cont'd)

Figures 11, 12: Alisporites thomasii (Couper) Pocock; 11-distal view, 68 x 40 microns, F2815-2824 (Clearwater Formation, Shale Member); 12 - distal view, 54 x 44 microns, W1781-1791 (Grand Rapids Formation); known range: Upper Jurassic to Lower Cretaceous . . (p. 226)

Figures 13, 14: Alisporites rotundus Rouse; 13 - distal view, 112 x 68 microns, F2815-2824 (Clearwater Formation, Shale Member); 14 - equatorial view, 104 x 63 microns, F2815-2824 (Clearwater Formation, Shale Member); known range: Upper Jurassic? to Lower Cretaceous (p. 227)



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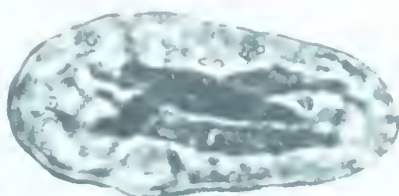
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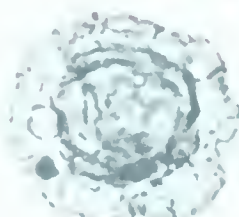
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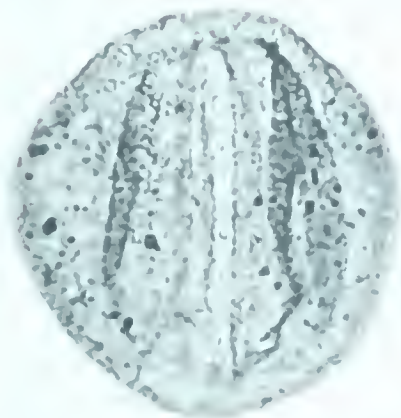
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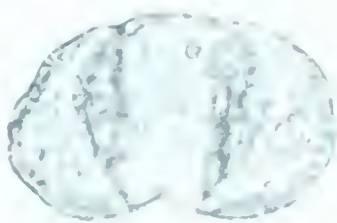
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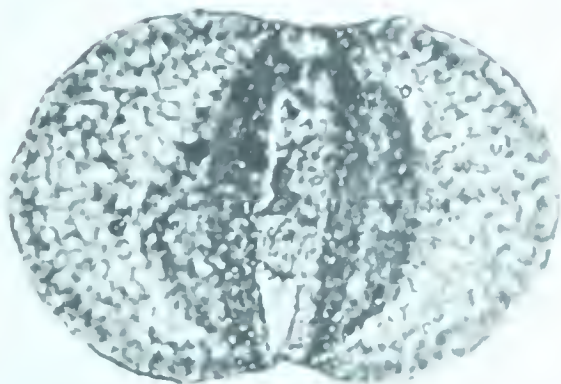
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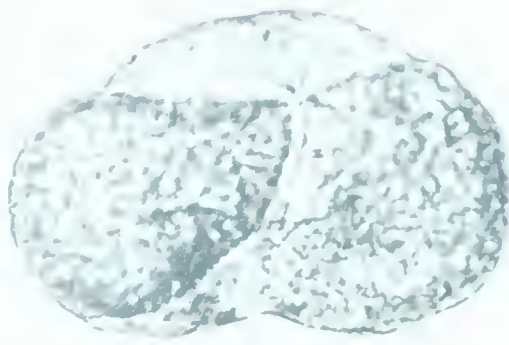
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EXPLANATION OF PLATE 15

All specimens are illustrated at a magnification of X 500 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
Depth position in well is in feet.

Figures 1,2: Alisporites rotundus Rouse; 1 - proximal view, 82 x 58 microns, W1816-1826 (Grand Rapids Formation); 2 - distal view, 102 x 90 microns, F2860-2869 (Clearwater Formation, Shale Member); known range: Upper Jurassic? to Lower Cretaceous. (p. 227)

Figures 3-5: Cedripites cretaceus Pocock; 3 - equatorial view, 78 x 48 microns, F3084-3093 (Ellerslie Member); 4 - equatorial view, 78 x 48 microns, F2514-2523 (Grand Rapids Formation); 5 - equatorial view, 86 x 54 microns, F2782-2785 (Clearwater Formation, Shale Member); known range: Barremian? to Albian (p. 228)

Figure 6: Cedripites canadensis Pocock; equatorial view, 60 x 37 microns, F3174-3179 (Ellerslie Member); known range: Barremian? to Middle Albian. (p. 230)

Figure 7: Parvisaccites radiatus Couper; equatorial view, 52 x 38 microns, F3010-3019 (Ellerslie Member); known range: Berriasian to Aptian (p. 231)

Figures 8,9: Phyllocladidites mawsonii forma verrucosus (Cookson) n. comb.; 8 - equatorial view, 50 x 28 microns, F2896-2905 (Wabiskaw Member); 9 - equatorial view, 56 x 32 microns, F3075-3084 (Ellerslie Member); known range: Lower Cretaceous to Lower Eocene. (p. 232)

Figure 10: Phyllocladidites sp.; distal view, 62 x 60 microns, F2932-2938 (Wabiskaw Member); known range: Middle Albian. (p. 234)

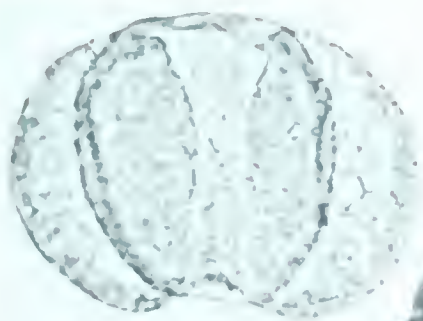
Figure 11: Podocarpidites cf. P. ellipticus Cookson; distal view, 70 x 43 microns, W1781-1791 (Grand Rapids Formation); known range: Jurassic to Tertiary. (p. 235)

Figures 12,13: Podocarpidites multesimus (Bolkhovitina) Pocock; 12 - proximal view, 70 x 36 microns, N3582-3592 (Calcareous Member); 13 - distal view, 68 x 28 microns, N3696-3706 (Ellerslie Member); known range: Jurassic to Cretaceous. (p. 237)

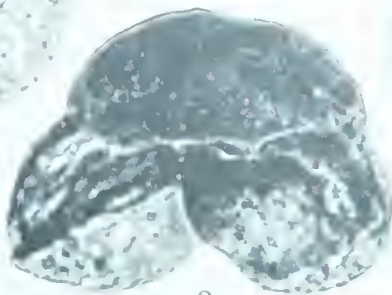
EXPLANATION OF PLATE 15 (cont'd)

Figure 14: Podocarpidites ornatus Pocock; proximal view, 94 x 61 microns,
F3165-3174 (Ellerslie Member); known range: Barremian? to Aptian (p. 238)

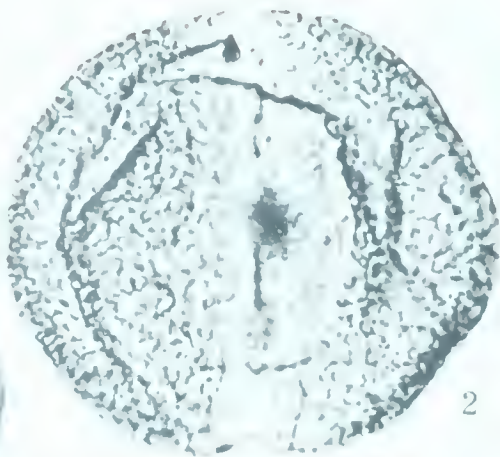
Figures 15,16: Podocarpidites minisculus n. sp.; 15 - (holotype) distal
view, 51 x 40.8 microns, F2689-2699 (Clearwater Formation,
Shale Member); 16 - equatorial view, 60 x 32 microns, F2598-
2607 (Grand Rapids Formation); known range: Barremian? to
Middle Albian. (p. 239)



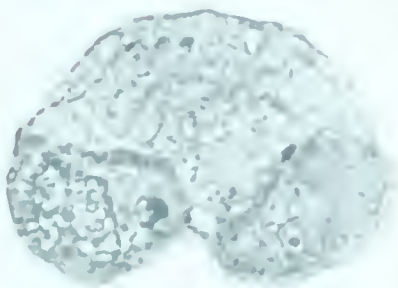
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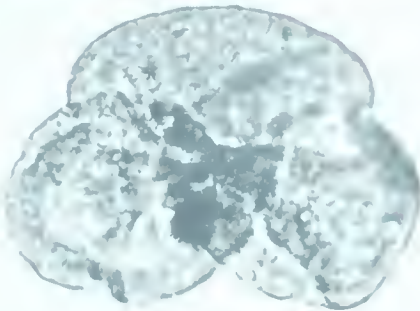
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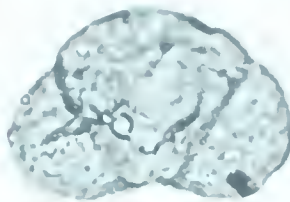
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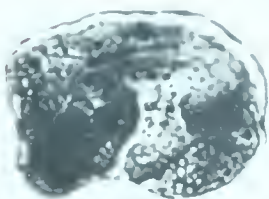
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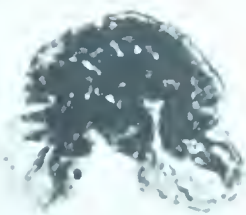
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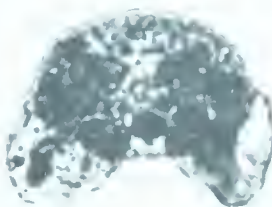
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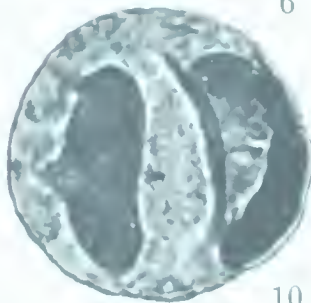
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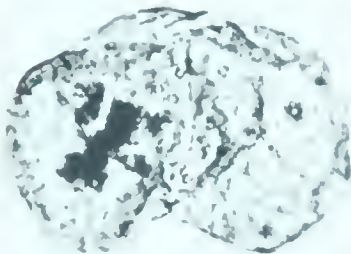
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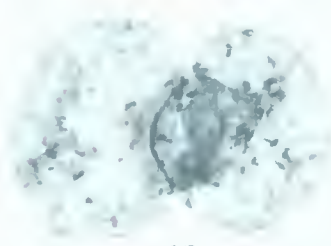
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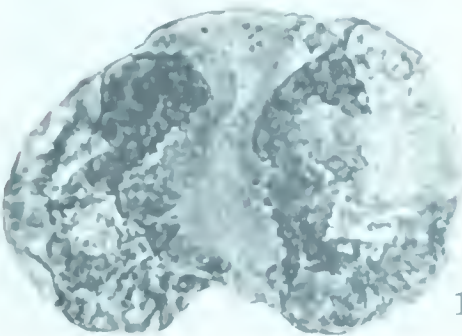
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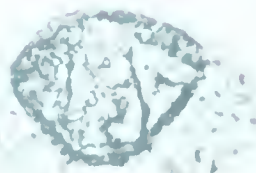
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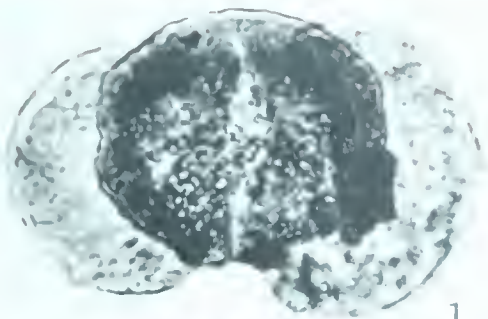
EXPLANATION OF PLATE 16

All specimens are illustrated at a magnification of X 500 unless otherwise stated

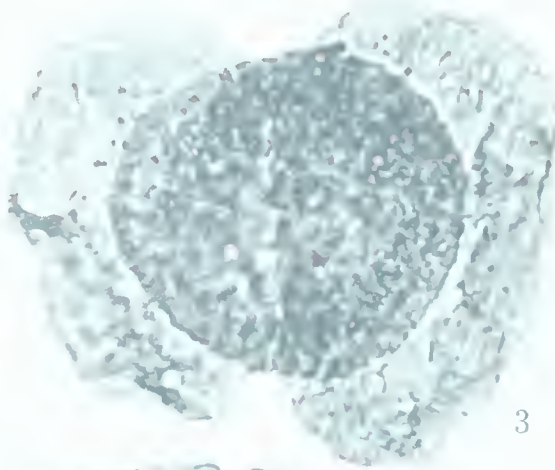
Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
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 Depth position in well is in feet.

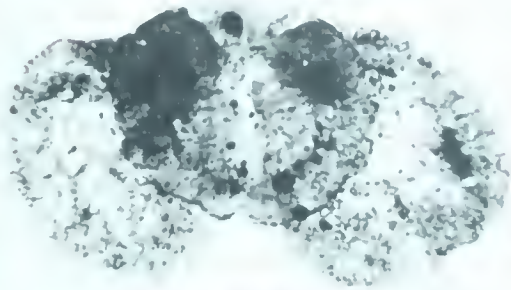
- Figures 1-3: Podocarpidites canadensis Pocock; 1 - proximal view, 98 x 54 microns, F3174-3179 (Ellerslie Member); 2 - proximal view, 104 x 46 microns, N3582-3592 (Calcareous Member); 3 - proximal view, 112 x 68 microns, F3093-3102 (Ellerslie Member); known range: Barremian? to Aptian. (p. 240)
- Figure 4: Aberrant Podocarpidites pollen; equatorial view, 63 x 36 microns, F2932-2938 (Wabiskaw Member) (p. 241)
- Figure 5: Podocarpidites sp.; proximal view, 142 x 92 microns, F3174-3179 (Ellerslie Member); known range: Barremian? (p. 242)
- Figure 6: Podocarpidites naumovai n. name; distal view, 116 x 66 microns, F2782-2785 (Clearwater Formation, Shale Member); known range: Albian to Cenomanian (p. 243)
- Figure 7: Piceapollenites sp.; equatorial end view, 120 x 112 microns, F2905-2914 (Wabiskaw Member); known range: Middle Albian. (p. 244)
- Figures 8, 9: Pityosporites constrictus n. sp.; 8 - (holotype) distal view, 74 x 42 microns, F3010-3019 (Ellerslie Member); 9 - distal view, 76 x 47 microns, N3778-3784 (Ellerslie Member); known range: Barremian? to Middle Albian. (p. 246)
- Figure 10: Pityosporites alatipollenites (Rouse) n. comb.; equatorial view, 66 x 42 microns, W1826-1836 (Grand Rapids Formation); known range: Upper Jurassic? to Upper Cretaceous. (p. 247)
- Figure 11: Aberrant Pityosporites pollen, equatorial view, 56 microns, F3174-3179 (Ellerslie Member). (p. 248)



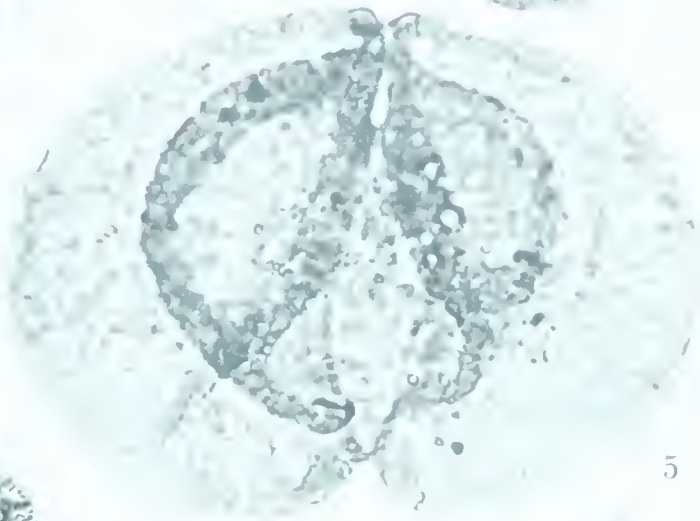
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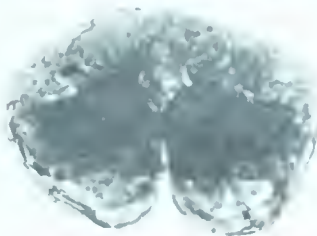
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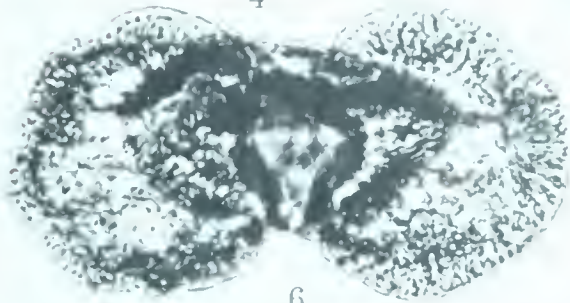
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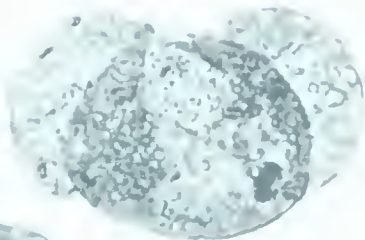
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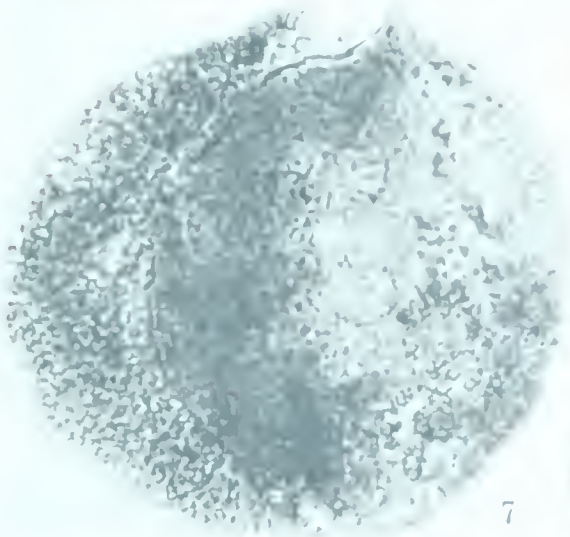
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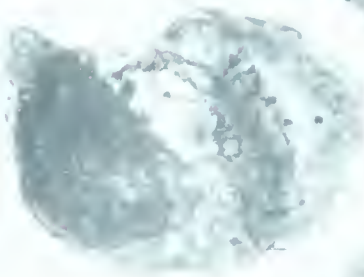
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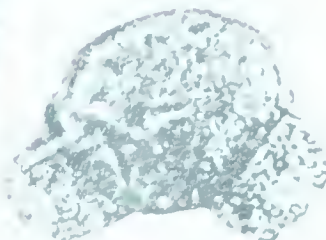
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EXPLANATION OF PLATE 17

All specimens are illustrated at a magnification of X 500 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

Figure 1: Tsugaepollenites mesozoicus Couper; distal view, 59 microns, N3748-3758 (Ellerslie Member); known range: Jurassic to Cretaceous. . . (p. 249)

Figure 2: Classopollis classoides (Pflug) Pocock and Jansonius; a tetrad, 28 x 23 microns (size of single pollen), N3726-3736 (Ellerslie Member); known range: Jurassic to Cretaceous. (p. 250)

Figure 3: Leioaletes calvatus n. sp.; (holotype), 67 x 28 microns, F2478-2487 (Grand Rapids Formation); known range: Middle Albian (p.252)

Figures 4, 5: Exesipollenites tumulus Balme; 4 - 30 microns, F2782-2785 (Clearwater Formation, Shale Member); 5 - 28 microns, W2095-2098 (Wabiskaw Member); known range: Triassic to Upper Cretaceous (p. 253)

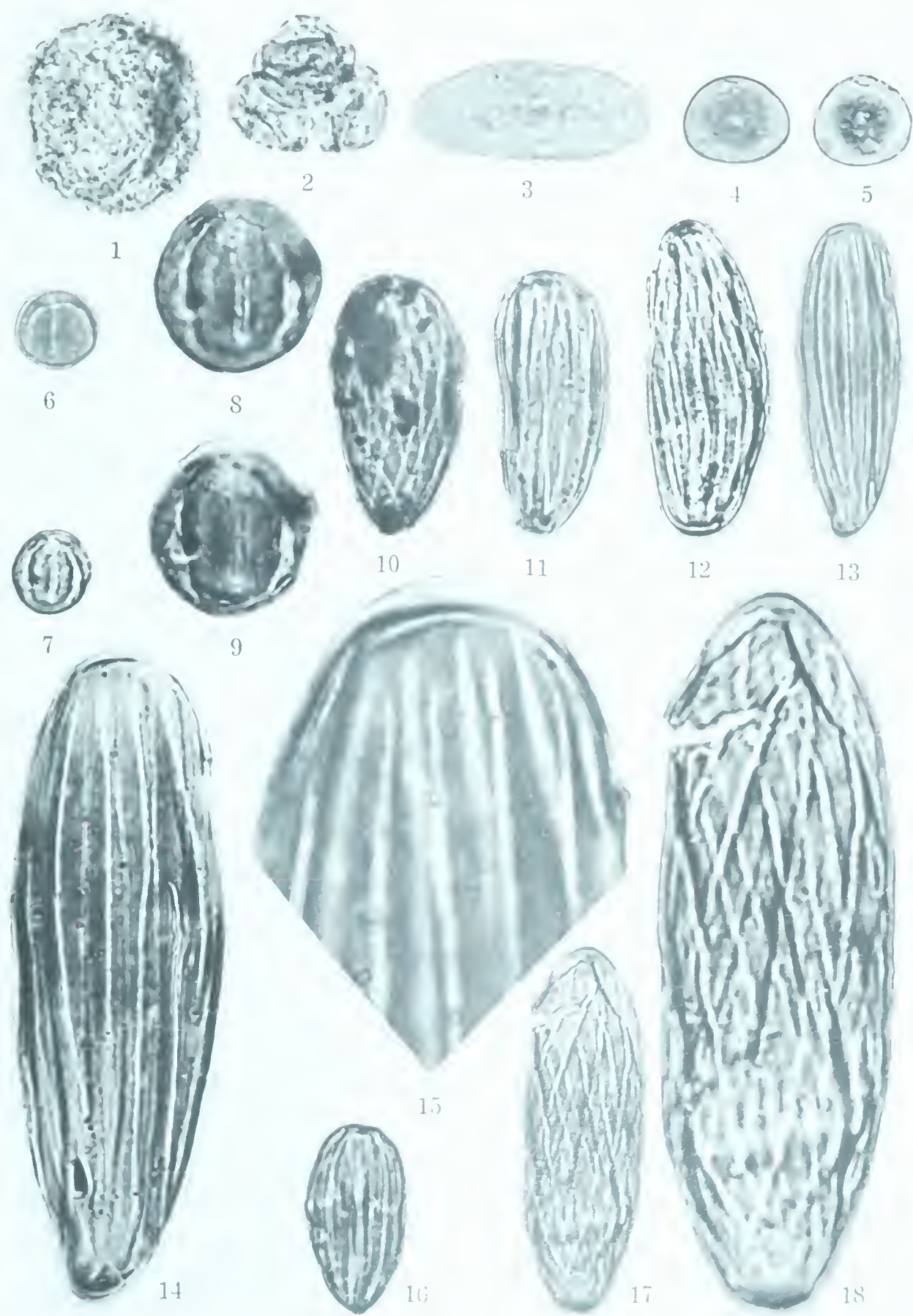
Figures 6-9: Eucommiidites troedssonii Erdtman; 6 - 23 x 24 microns, W2095-2098 (Wabiskaw Member); 7 - 24 x 23 microns, F2607-2616 (Grand Rapids Formation); 8 - same specimen X1024 showing the median furrow; 9 - same specimen X1024 showing the ring-furrow on the opposite face; known range: Jurassic to Lower Cretaceous. (p. 255)

Figures 10-15: Equisetosporites concinnus n. sp.; 10 - 75 x 40 microns, N3850-3860 (Ellerslie Member); 11 - 78 x 34 microns, N3850-3860 (Ellerslie Member); 12 - 90 x 36 microns, N3850-3860 (Ellerslie Member); 13 - (holotype) mid-focus, 92 x 32 microns, N3850-3860 (Ellerslie Member); 14 - (holotype) X 1024 focussed on upper surface to show the width of ridges and furrows; 15 - (holotype) X 1967 showing coalescing ridges before reaching the longitudinal ends; known range: Barremian? (p. 259)

Figure 16: Equisetosporites cf. E. ovatus (Pierce) n. comb.; 54 x 28 microns, F3046-3054 (Ellerslie Member); known range: Barremian? to Cenomanian. (p. 264)

EXPLANATION OF PLATE 17 (cont'd)

Figures 17, 18: Equisetosporites albertensis n. sp.; 17 - (holotype) mid-focus,
104 x 34 microns, N3850-3860 (Ellerslie Member); 18 - (holotype)
X 1024 mid-focus; known range: Barremian? (p. 265)



EXPLANATION OF PLATE 18

All specimens are illustrated at a magnification of X 500 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

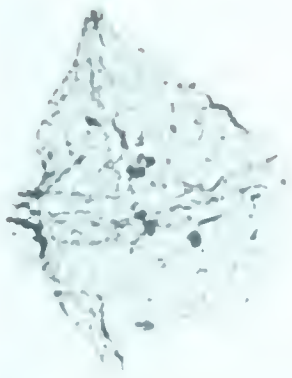
Figure 1: Palaeoperidinium cretaceum Pocock; 84 x 58 microns, F2598-2607 (Grand Rapids Formation); known range: Cretaceous. . . . (p. 267)

Figures 2,3: Palaeoperidinium granulatum n. sp.; 2 - 110 x 85 microns, F2598-2607 (Grand Rapids Formation); 3 - (holotype) 100 x 83 microns, F2598-2607 (Grand Rapids Formation); known range: Middle Albian. (p. 268)

Figure 4: Gonyaulax cf. G. jurassica Deflandre; 112 x 98 microns, F2607-2616 (Grand Rapids Formation); known range: Oxfordian to Middle Albian? (p. 270)

Figure 5: Hystriosphæridium tubiferum (Ehrenberg) Deflandre; 80 microns (including processes), W2095-2098 (Wabiskaw Member); known range: Barremian to Senonian (p. 272)

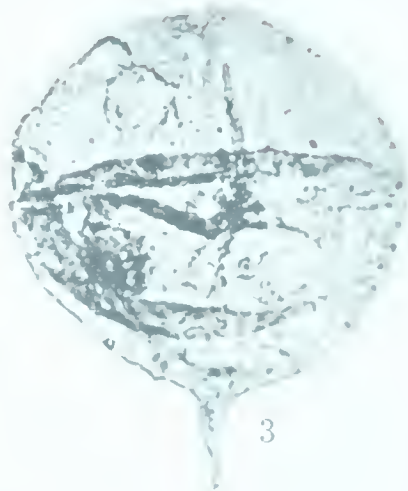
Figures 6,7: Hystriosphæridium albertense Pocock; 6 - 94 microns (including processes), W2095-2098 (Wabiskaw Member); 7 - 108 microns (including processes), W2098-2101 (Wabiskaw Member); known range: Barremian? to Middle Albian. (p. 273)



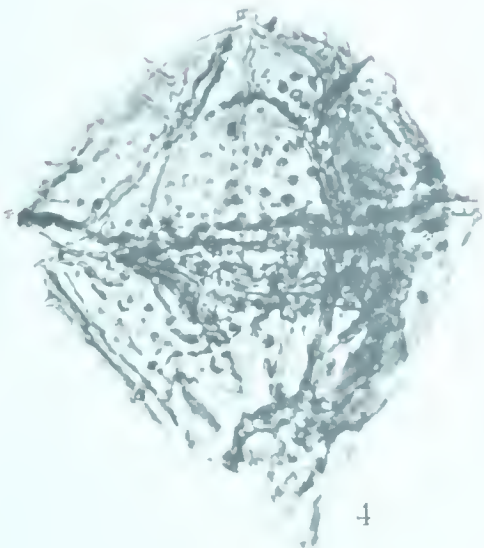
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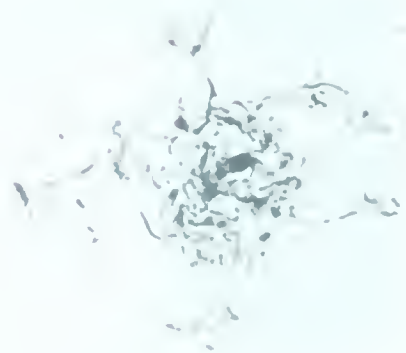
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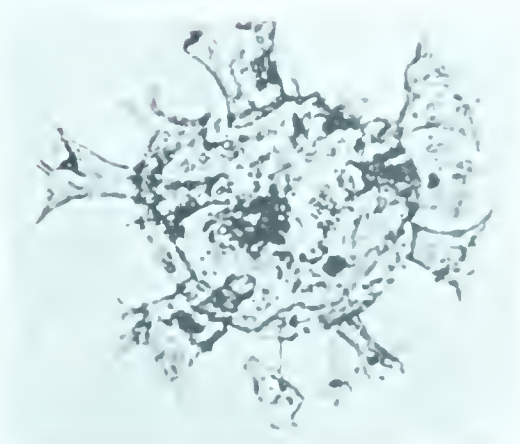
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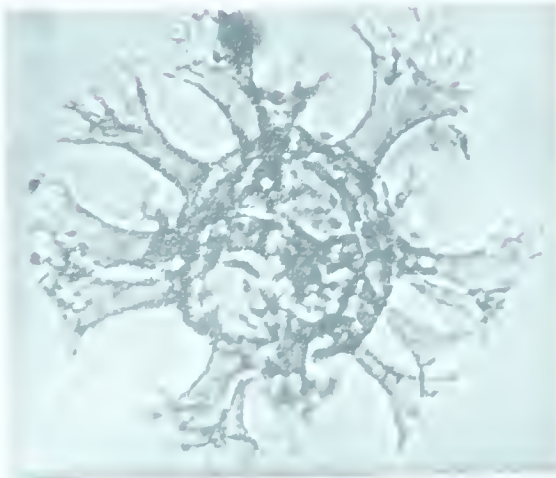
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EXPLANATION OF PLATE 19

All specimens are illustrated at a magnification of X 500 unless otherwise stated

Locality code

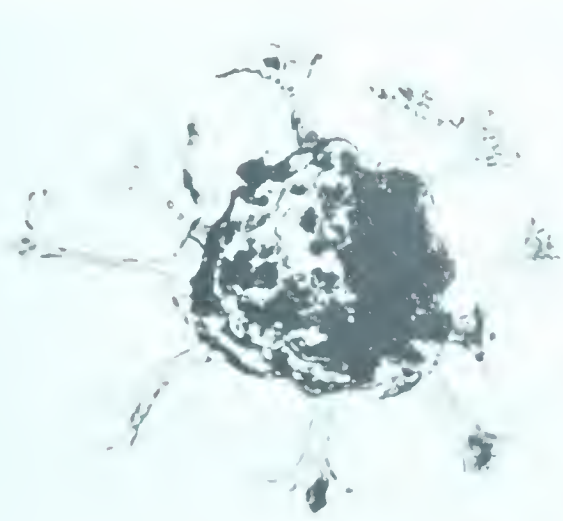
N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

Figures 1-4: Hystriosphæridium irregulare Pocock; 1 - 124 microns
 (including processes), W2055-2065 (Wabiskaw Member); 2, 3, 4 -
 same specimen X 1024 showing irregular nature of processes;
 known range: Upper Barremian? to Middle Albian. (p. 274)

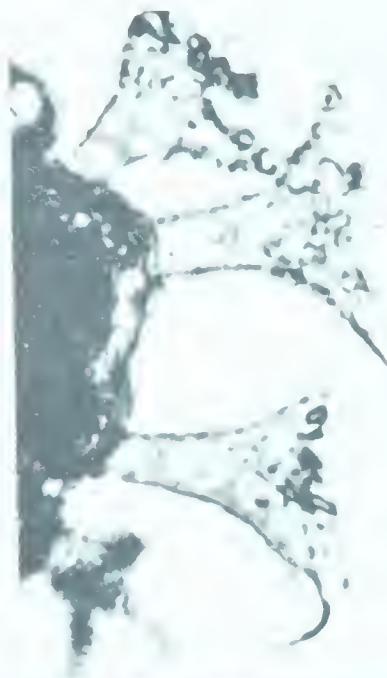
Figure 5: Baltisphaeridium longispinosum (Eisenack) Eisenack; 100
 microns (including processes), W1816-1826 (Grand Rapids
 Formation); known range: Reworked from Ordovician. (p. 276)

Figures 6, 7: Baltisphaeridium cf. B. neptuni Eisenack; 6 - 60 microns
 (including processes), F2717-2725 (Clearwater Formation, Shale
 Member); 7 - same specimen X 1024 showing nature of processes;
 known range: Aptian to Middle Albian. (p. 277)

Figure 8: Baltisphaeridium sp.; 37 microns (including processes),
 F2717-2725 (Clearwater Formation, Shale Member); known
 range: Middle Albian. (p. 278)



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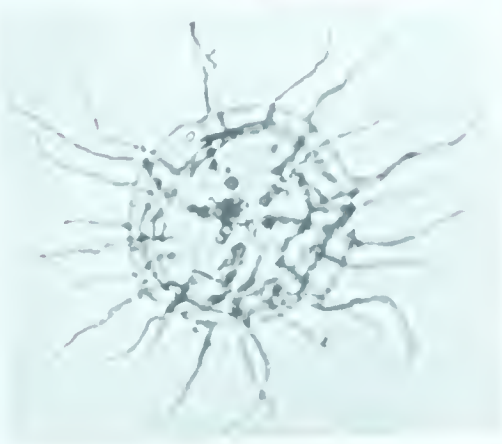
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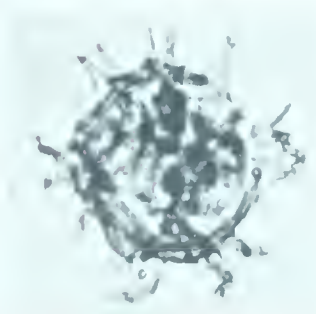
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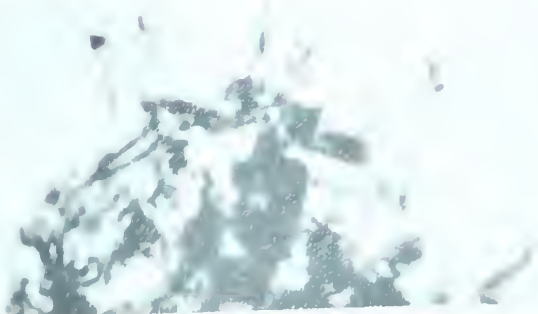
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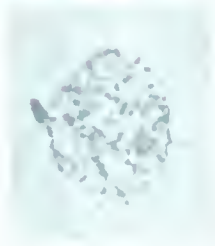
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EXPLANATION OF PLATE 20

All specimens are illustrated at a magnification of X 500 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

Figures 1,2: Baltisphaeridium multispinosum n. sp.; 1 - (holotype) 62 microns (including processes), W2098-2101 (Wabiskaw Member); 2 - 74 microns (including processes), W2098-2101 (Wabiskaw Member); known range: Middle Albian. (p. 279)

Figure 3: Verhachium reductum (Deunff) Jekhowsky; 62 microns (diameter including processes), W1816-1826 (Grand Rapids Formation); known range: Ordovician to Cenomanian (p. 280)

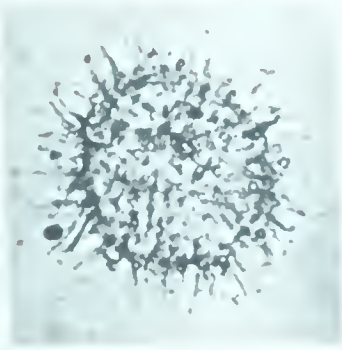
Figure 4: Verhachium irregulare forma subhexahedron Jekhowsky; diameter of central body 20.4 microns, processes 10 microns, W1816-1826 (Grand Rapids Formation); known range: Permian to Middle Albian? (p. 282)

Figures 5,6: Pseudoceratium pelliferum Gocht; 5 - 92 x 68 microns, F2607-2616 (Grand Rapids Formation); 6 - 90 x 61 microns, F2598-2607 (Grand Rapids Formation); known range: Valanginian to Middle Albian. (p. 283)

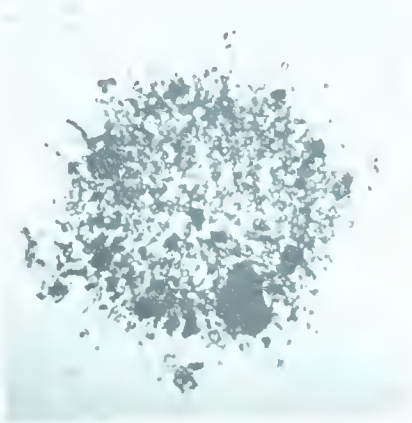
Figure 7: Pseudoceratium gochtii Pocock; 93.5 x 34 microns, F2782-2785 (Clearwater Formation, Shale Member); known range: Cretaceous. (p. 285)

Figure 8: Canningia colliveri Cookson and Eisenack; 102 x 70 microns, W2085-2095 (Wabiskaw Member); known range: Aptian to Middle Albian. (p. 286)

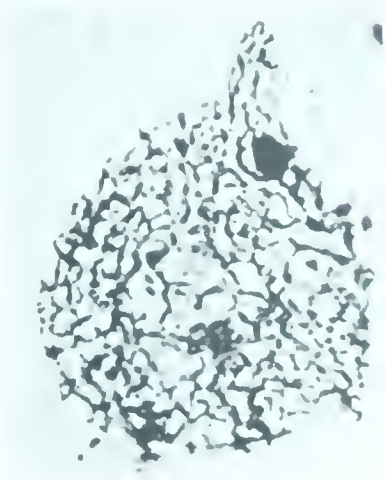
Figures 9,10: Odontochitina operculata (Wetzel) Deflandre; 9 - 300 x 44 microns, F2717-2725 (Clearwater Formation, Shale Member); 10 - longer antapical horn broken, F2717-2725 (Clearwater Formation, Shale Member); known range: Hauterivian to Upper Cretaceous. (p. 288)



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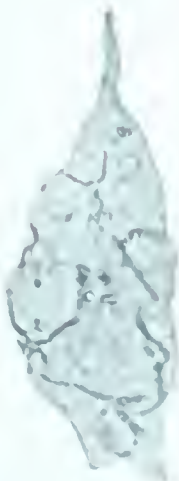
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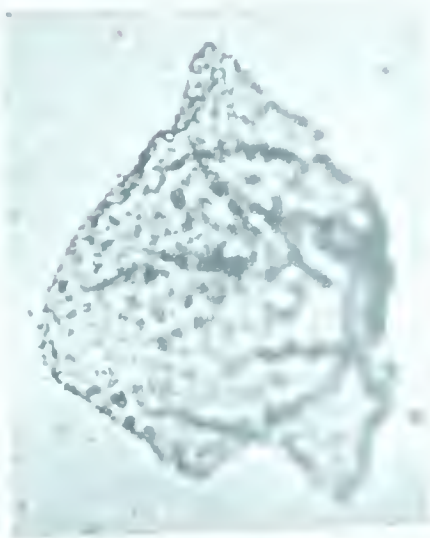
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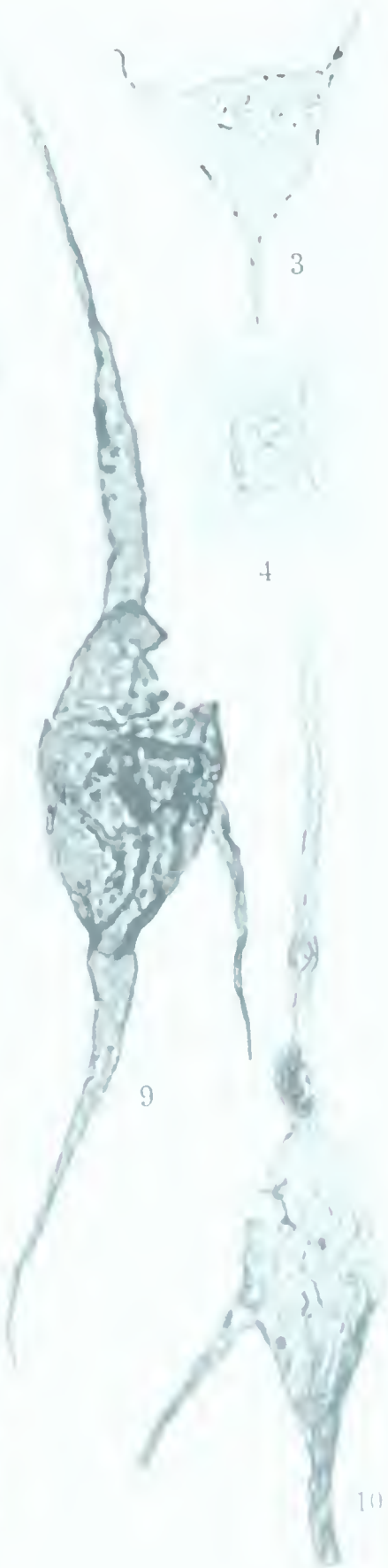
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EXPLANATION OF PLATE 21

All specimens are illustrated at a magnification of X 100 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

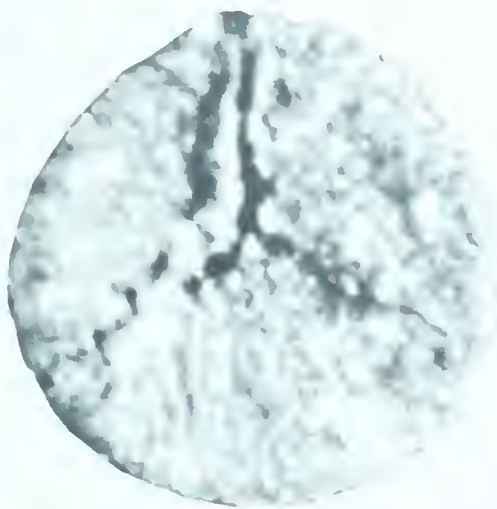
Figure 1: Triletes persimilis Harris; proximal view, 510 microns, W1816-1826 (Grand Rapids Formation); known range: Rhaetic-Liassic to Senonian. (p. 292)

Figure 2: Triletes sp. A; proximal view, 641 microns, F3111-3120 (Ellerslie Member); known range: Barremian? (p. 293)

Figure 3: Triletes sp. B; proximal view, 397 microns, F3111-3120 (Ellerslie Member); known range: Barremian? (p. 293)

Figures 4, 5: Horstisporites reticuliferus (Dijkstra) Potonie; 4 - proximal view, 470 microns, F3188-3197 (Ellerslie Member); 5 - proximal view, 840 microns, F3188-3197 (Ellerslie Member); known range: Neocomian. (p. 294)

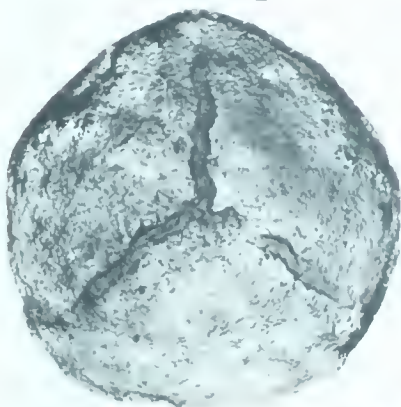
Figure 6: Verrutrites cf. V. compositipunctatus (Van der Hammen) Potonie; proximal view, 330 microns, N3572-3582 (Wabiskaw Member); known range: Barremian? to Senonian (p. 295)



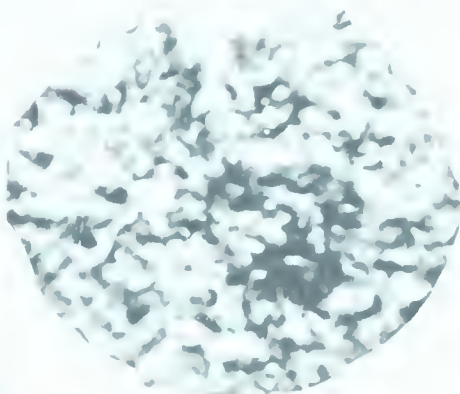
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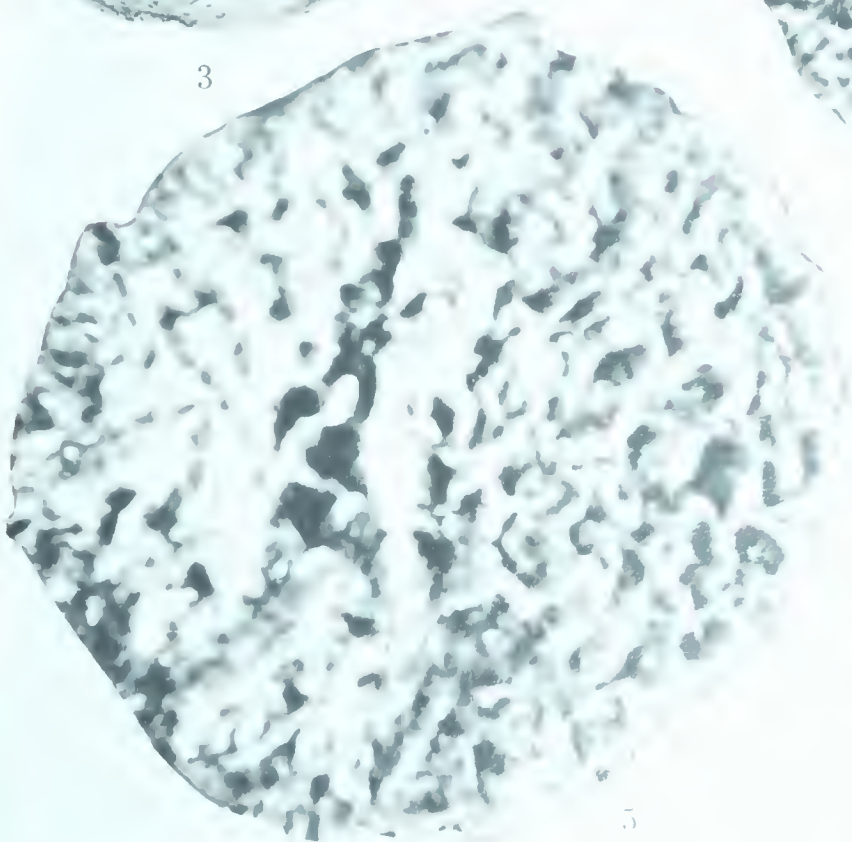
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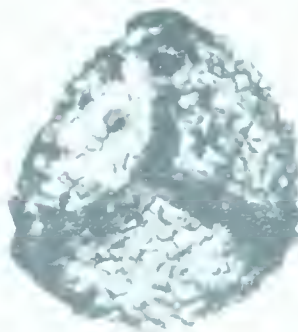
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EXPLANATION OF PLATE 22

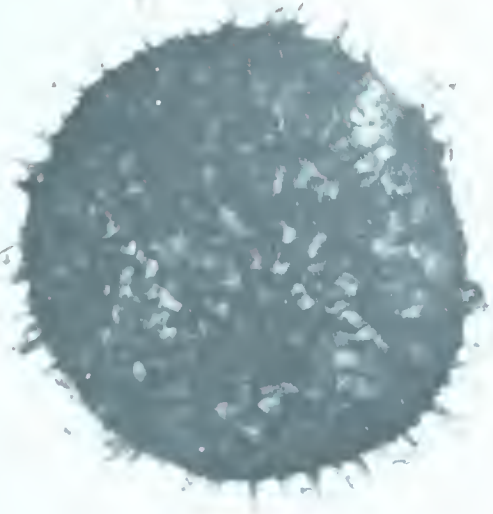
All specimens are illustrated at a magnification of X 100 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

Figures 1,2: Erlansonisporites reticulatus n. sp.; 1 - (holotype) distal view, 580 microns (including lamellae), F2460-2469 (Grand Rapids Formation); 2 - proximal view, 660 microns (including lamellae), F3156-3165 (Ellerslie Member); known range: Barremian? to Middle Albian. . (p. 297)

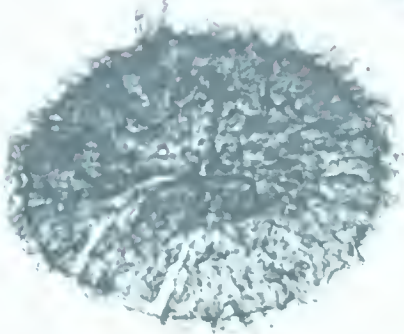
Figures 3-9: Erlansonisporites sparassis? (Murray) Potonie; 3 - proximal view, 410 microns (including lamellae), F3001-3010 (Ellerslie Member); 4 - distal view, 450 microns (including lamellae), F3093-3102 (Ellerslie Member); 5 - proximal view, 300 microns, F3093-3102 (Ellerslie Member); 6 - proximal view, 480 microns, F3093-3102 (Ellerslie Member); 7 - distal view, 450 microns, F3093-3102 (Ellerslie Member); 8 - proximal view, 450 microns, F3093-3102 (Ellerslie Member); 9 - proximal view, 450 microns, F3093-3102 (Ellerslie Member); known range: Middle Jurassic to Aptian? . . . (p. 298)



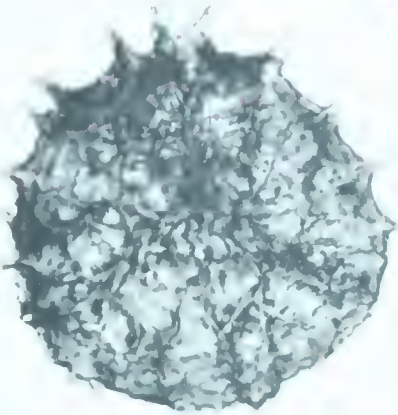
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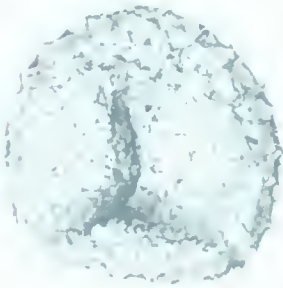
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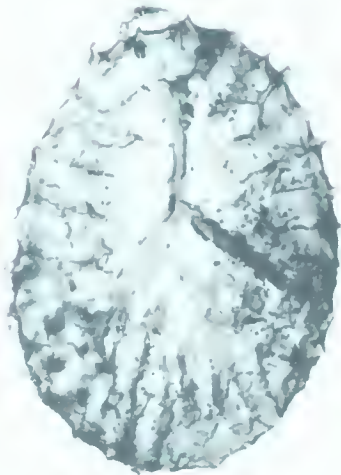
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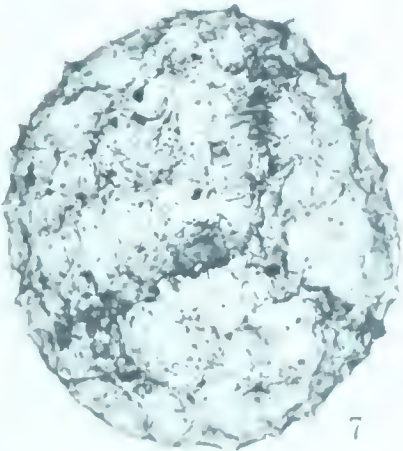
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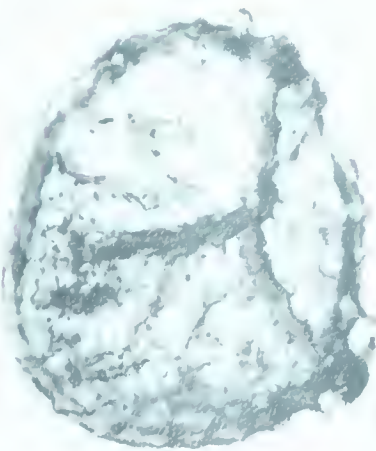
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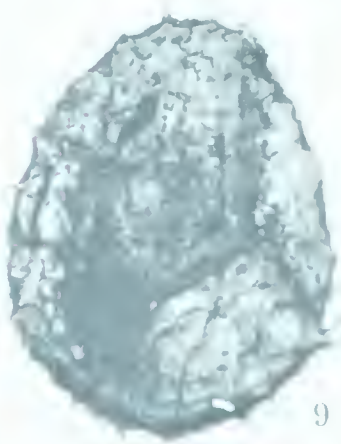
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EXPLANATION OF PLATE 23

All specimens are illustrated at a magnification of X 100 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

Figures 1,2: Erlansonisporites globosus n. sp.; 1 - (holotype) proximal view, 372 microns, F3001-3010 (Ellerslie Member); 2 - proximal view, 320 microns, F3156-3165 (Ellerslie Member); known range: Barremian? to Aptian. (p. 299)

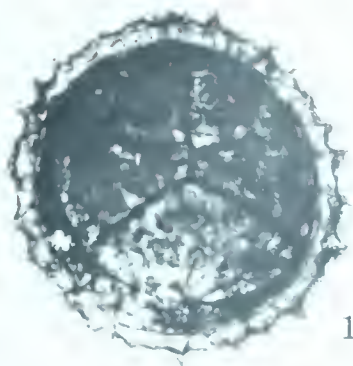
Figure 3: Erlansonisporites sp.; 230 microns, F3222-3231 (Dewille Member); known range: Barremian? (p. 300)

Figure 4: Maexisporites soldanellus (Dijkstra) Potonie; proximal view, 384 microns, F3093-3102 (Ellerslie Member); known range: Berriasian to Aptian (p. 302)

Figures 5,6: Maexisporites obolus (Dijkstra) Potonie; 5 - proximal view, 280 microns, F3222-3231 (Dewille Member); 6 - proximal view, 224 microns, F3093-3102 (Ellerslie Member); known range: Hauterivian to Barremian. (p. 303)

Figure 7: Thomsonia phyllicus (Murray) Potonie; equatorial view, 420 microns (diameter of body and height of triradiate lamellae), F3093-3102 (Ellerslie Member); known range: Middle Jurassic to Lower Cretaceous (p. 304)

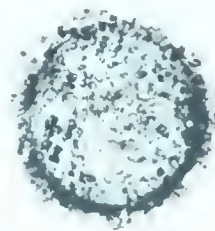
Figures 8-11: Minerisporites macroreticulatus n. sp.; 8 - (holotype) proximal view, 500 microns, F2442-2451 (Grand Rapids Formation); 9 - proximal view, 390 microns, F2442-2451 (Grand Rapids Formation); 10 - proximal view, equatorial zona mostly lost, present only at apices where it is strengthened by triradiate lamellae, 520 microns, F2478-2487 (Grand Rapids Formation); 11 - equatorial view, 580 microns (diameter of body and height of triradiate lamellae), F2478-2487 (Grand Rapids Formation); known range: Middle Albian. (p. 305)



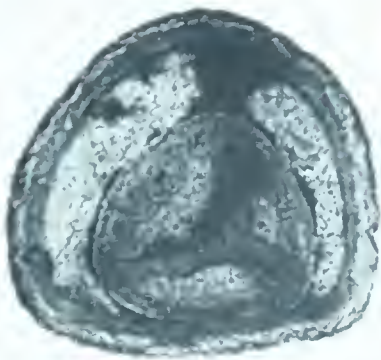
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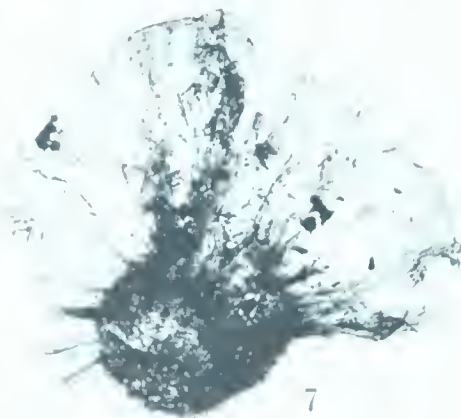
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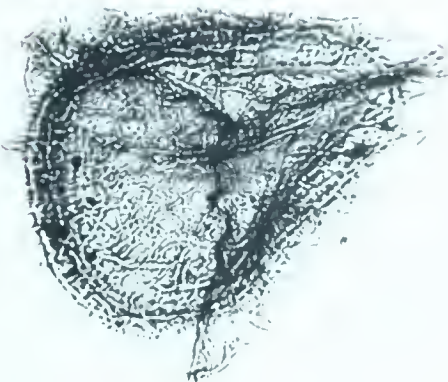
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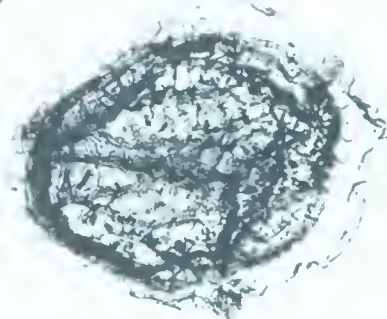
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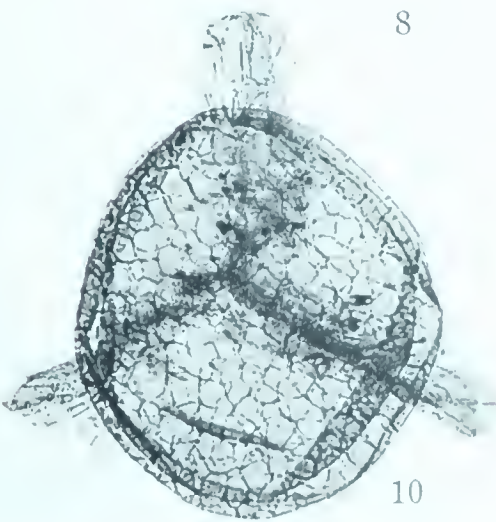
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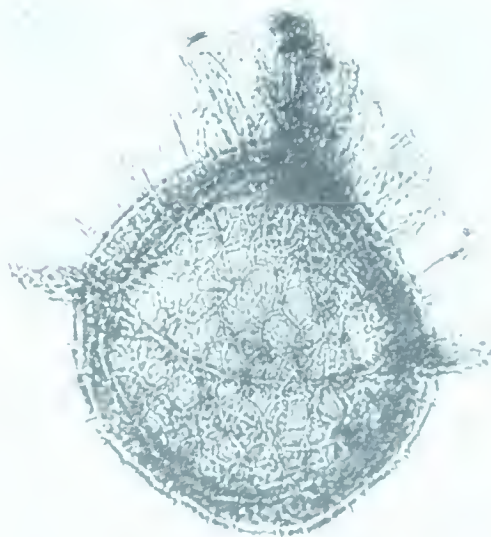
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EXPLANATION OF PLATE 24

All specimens are illustrated at a magnification of X 100 unless otherwise stated

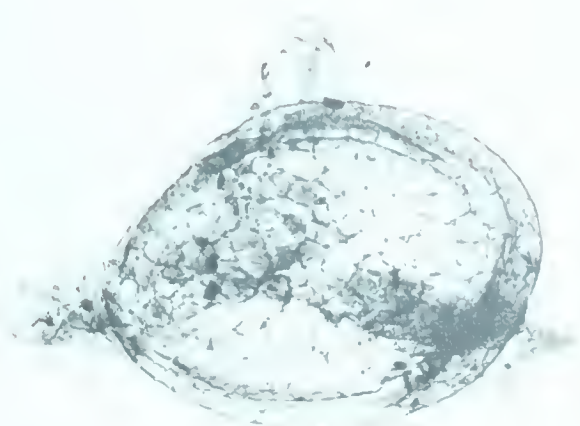
Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

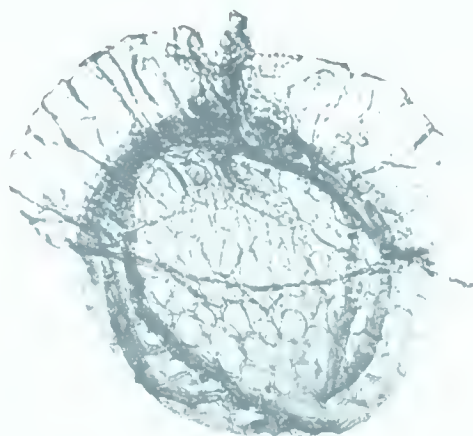
Figures 1,2: Minerisporites macroreticulatus n. sp.; 1 - proximal view, equatorial zona mostly lost, present only at apices where it is strengthened by triradiate lamellae, 570 microns, F2478-2487 (Grand Rapids Formation); 2 - equatorial view, 450 microns (diameter of body and height of triradiate lamellae), F2478-2487 (Grand Rapids Formation); known range: Middle Albian. (p. 305)

Figures 3-7: Minerisporites marginatus (Dijkstra) Potonie; 3 - proximal view, 290 microns, F3084-3093 (Ellerslie Member); 4 - proximal view, 320 microns, F3084-3093 (Ellerslie Member); 5 - proximal view, 350 microns, W1781-1791 (Grand Rapids Formation); 6 - equatorial view, 460 microns (diameter of body and height of triradiate lamellae), F3093-3102 (Ellerslie Member); 7 - equatorial view, 410 microns (diameter of body and height of triradiate lamellae), W1781-1791 (Grand Rapids Formation); known range: Lower Cretaceous. (p. 307)

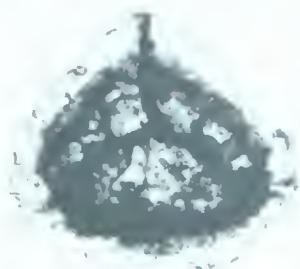
Figures 8,9: Minerisporites venustus n. sp.; 8 - (holotype) proximal view, 380 microns, F2442-2451 (Grand Rapids Formation); 9 - proximal view, 350 microns, F2442-2451 (Grand Rapids Formation); known range: Middle Albian (p. 308)



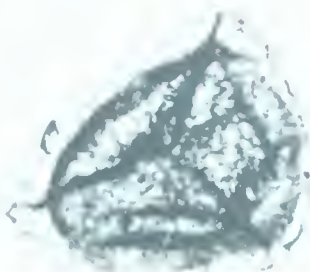
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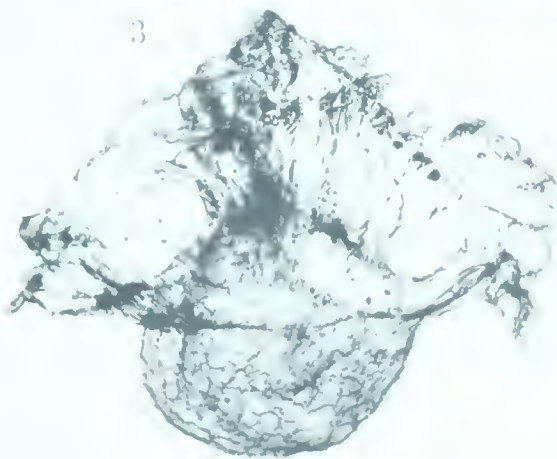
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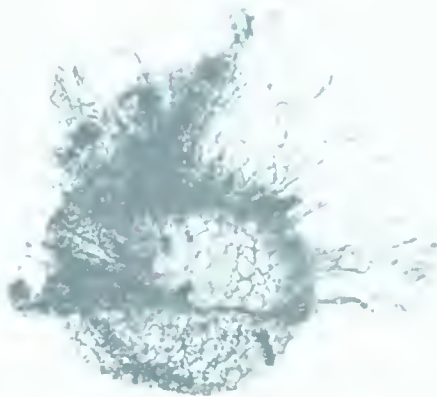
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EXPLANATION OF PLATE 25

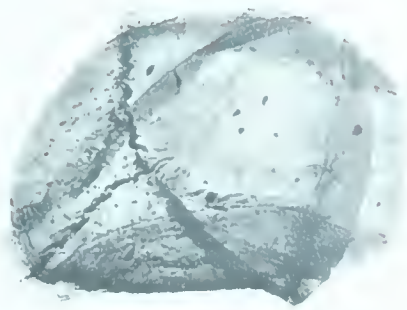
All specimens are illustrated at a magnification of X 100 unless otherwise stated

Locality code

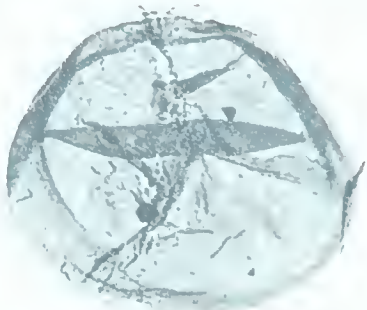
N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

Figures 1-6: Minerisporites venustus n. sp. 1 - proximal view, 430 microns, F2442-2451 (Grand Rapids Formation); 2 - proximal view, 360 microns, F2442-2451 (Grand Rapids Formation); 3 - proximal view, 400 microns, W1891-1901 (Grand Rapids Formation); 4 - proximal view, 410 microns, W2045-2055 (Clearwater Formation, Shale Member); 5 - proximal view, 384 microns, W2045-2055 (Clearwater Formation, Shale Member); 6 - proximal view, 320 microns, W1781-1791 (Grand Rapids Formation); known range: Middle Albian. (p. 308)

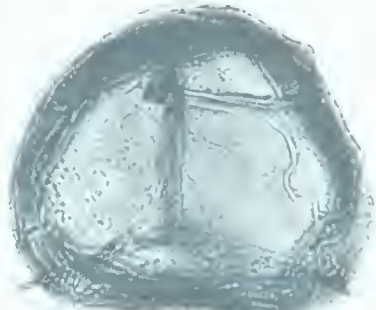
Figures 7-10: Dijkstraisporites helios (Dijkstra) Potonie; 7 - mid-focus, 615 microns, F3213-3222 (Deville Member); 8 - proximal view, 560 microns, F3213-3222 (Deville Member); 9 - proximal view, 560 microns, F3222-3231 (Deville Member); 10 - proximal view, 490 microns, F3213-3222 (Deville Member); known range: Barremian to Aptian. (p. 311)



1



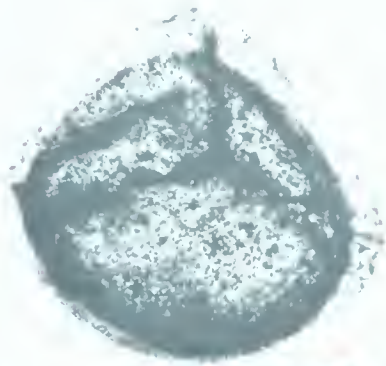
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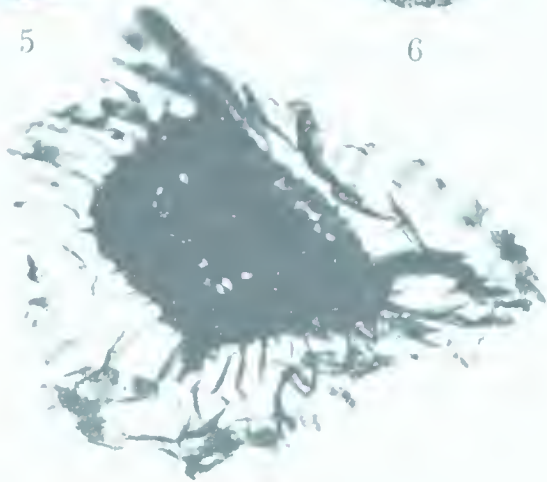
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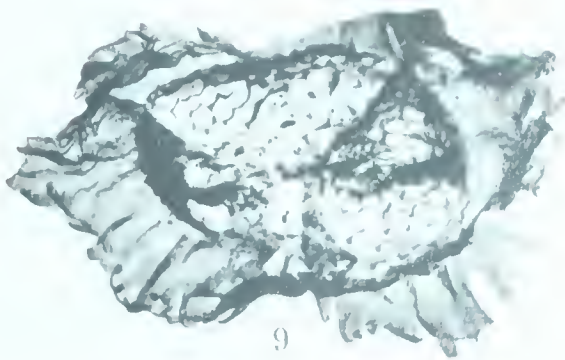
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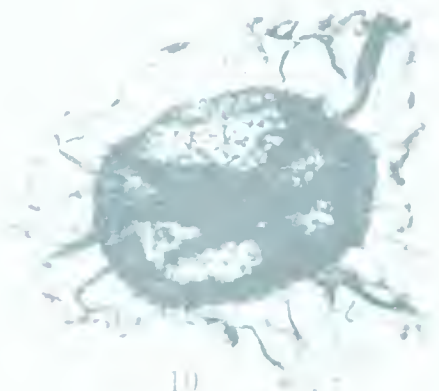
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EXPLANATION OF PLATE 26

All specimens are illustrated at a magnification of X 100 unless otherwise stated

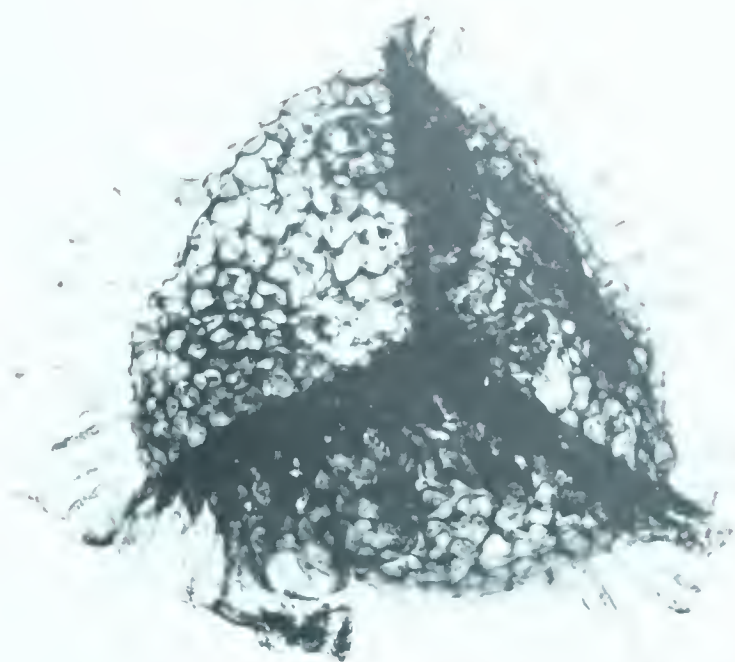
Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

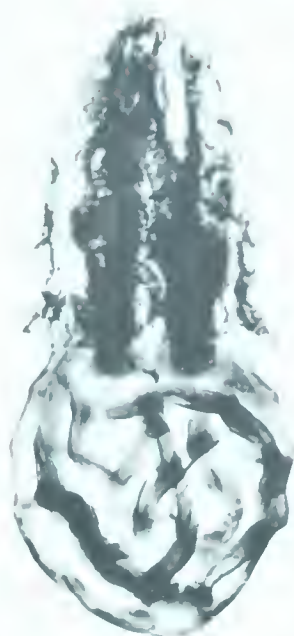
Figure 1: Dijkstraisporites triangulatus n. sp.; (holotype) proximal view,
 737.2 microns, F2923-2932 (Wabiskaw Member); known range:
 Middle Albian. (p. 312)

Figures 2-4: Arcellites rugosus n. sp.; 2 - (holotype) equatorial view,
 670 microns, N3632-3642 (Ellerslie Member); 3 - equatorial
 view, 560 microns, F3249-3257 (Deville Member); 4 - X 400
 part of ridge pattern enlarged from figure 2; known range:
 Barremian? to Aptian (p. 314)

Figures 5-7: Arcellites reticulatus (Cookson and Dettmann) n. comb.;
 5 - equatorial view, 577 microns, F2442-2451 (Grand Rapids
 Formation); 6 - equatorial view, 577 microns, F2442-2451
 (Grand Rapids Formation); 7 - same specimen X 200 part of
 reticulate pattern on the body; known range: Albian (p. 317)



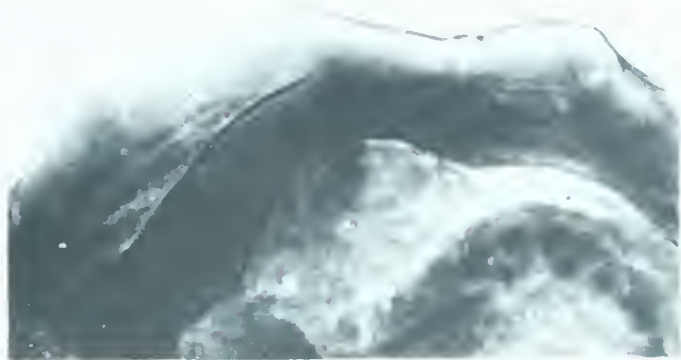
1



2



3



4



5



6



EXPLANATION OF PLATE 27

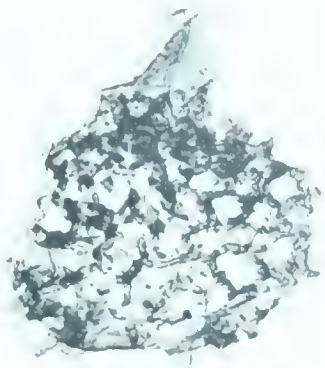
All specimens are illustrated at a magnification of X 100 unless otherwise stated

Locality code

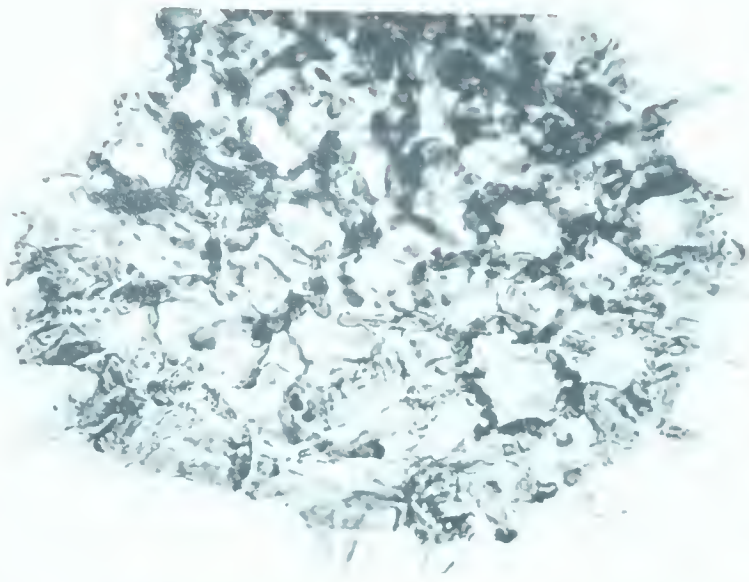
N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

Figures 1,2: Arcellites incipiens n. sp.; 1 - (holotype) equatorial view, 385 microns, F3001-3010 (Ellerslie Member); 2 - (holotype) X 250 reticulate pattern on the body; known range: Barremian? to Aptian (p. 318)

Figures 3-8: Arcellites nudus (Cookson and Dettmann) n. comb.; 3 - equatorial view, 641 microns, F2478-2487 (Grand Rapids Formation); 4 - equatorial view, 465 microns, F2442-2451 (Grand Rapids Formation); 5 - X 320 optical section of exine along the margin and pitted outer ectexine, enlarged from figure 3; 6,7 - X 630 granular inner ectexine at low focus (6 enlarged from figure 3 and 7 enlarged from figure 4); 8 - X 630 pitted outer ectexine at high focus, enlarged from figure 3; known range: Albian. (p. 320)



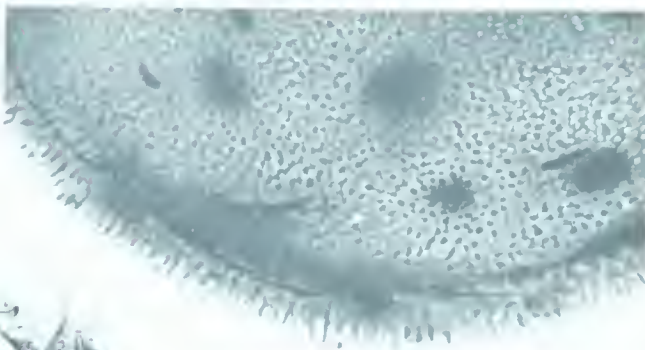
1



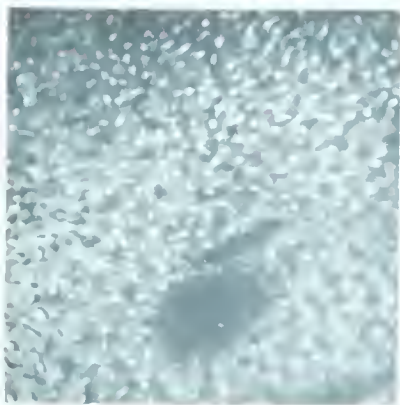
2



3



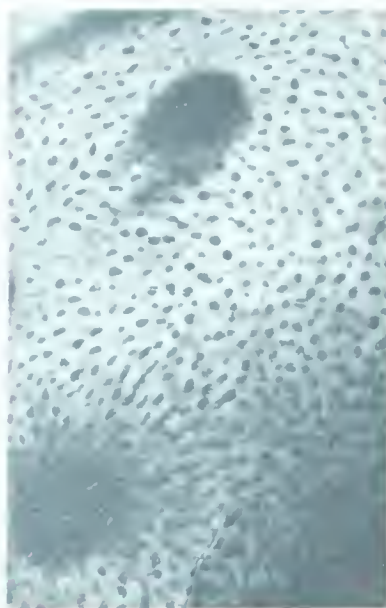
5



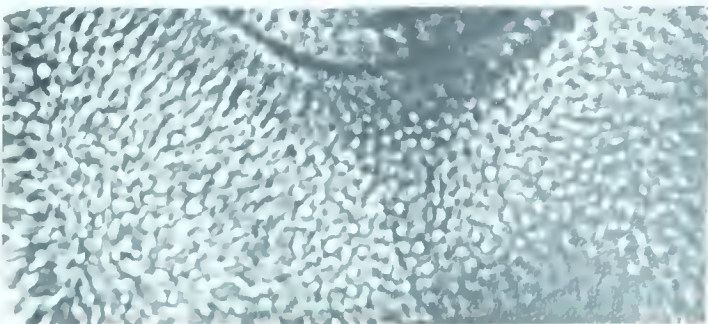
6



4



8



7

EXPLANATION OF PLATE 28

All specimens are illustrated at a magnification of X 100 unless otherwise stated

Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

Figures 1-5: Arcellites disciformis (Miner) Ellis and Tschudy; 1 - equatorial view, 490 microns, F3111-3120 (Ellerslie Member); 2 - equatorial view, 679.5 microns, F3019-3028 (Ellerslie Member); 3 - equatorial view, 500 microns, F3111-3120 (Ellerslie Member); 4 - X 400 granular inner etkexine at low focus enlarged from figure 1; 5 - X 400 pitted outer etkexine at high focus enlarged from figure 1; known range: Barremian? to Cenomanian. (p. 321)



EXPLANATION OF PLATE 29

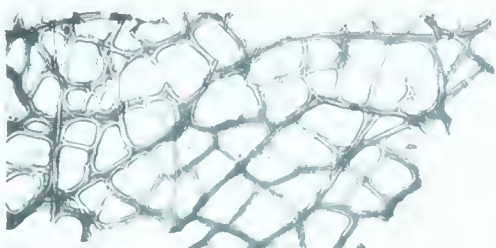
Locality code

N=Imperial Namao No. 1 well (Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.);
 F=Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.);
 W=Imperial Willingdon No. 1 well (Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.).
 Depth position in well is in feet.

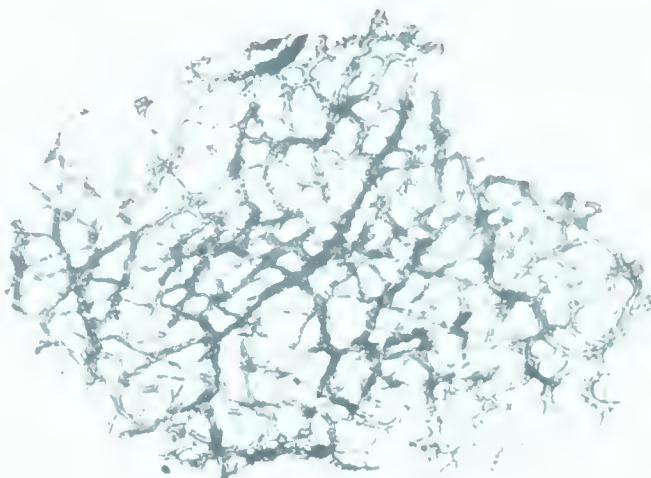
Figures 1-3: Dictyothylakos sp.; 1 - X 50.4, W1791-1801 (Grand Rapids Formation); 2 - X 63, F3222-3231 (Deville Member); 3 - X 127, W1791-1801 (Grand Rapids Formation); known range: Neocomian to Middle Albian. (p. 323)

Figure 4: Caytonia seed; X 64.5; length 705 microns, breadth 435 microns, W1846-1856 (Grand Rapids Formation); known range: Middle Albian. (p. 324)

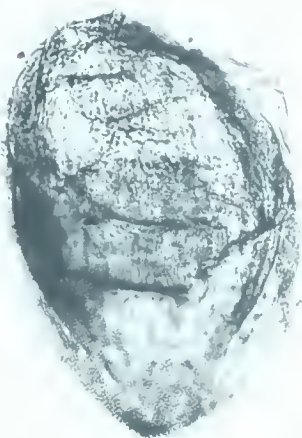
Figures 5-6: Nucellus cuticle of Caytonia seed?; 5 - X 50 front view, length 1100 microns, breadth 700 microns, F2992-3001 (Ellerslie Member); 6 - same specimen X 50 lateral view; known range: Barremian? (p. 325)



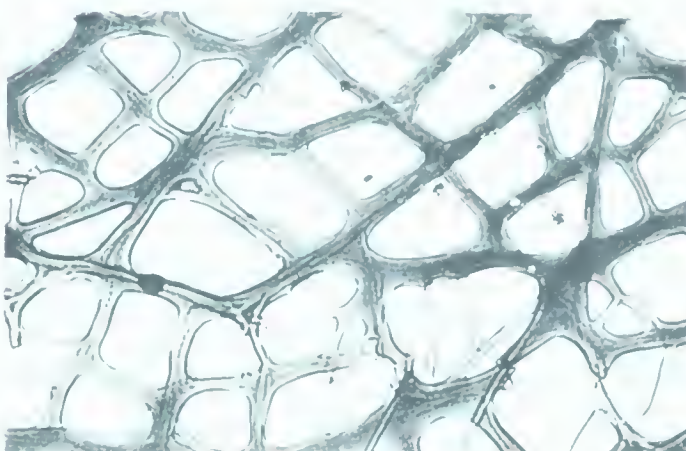
1



2



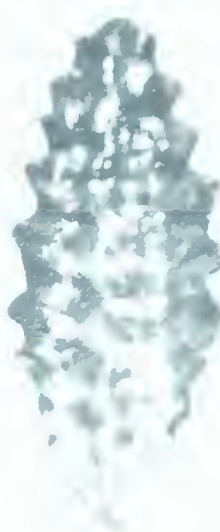
4



3



5



6

DISTRIBUTION AND
RELATIVE ABUNDANCE
OF THE MANNVILLE MICROFLORA
IN IMPERIAL NAMAO No.1
WELL (Lsd.12, Sec.22, Tp.54,
R.24, W. 4th Mer.)

LEGEND

Megospores

1

2

3 - 4

5 or more

* Index species

LOWER CRETACEOUS
MANNVILLE GROUP

EQU FORMATION

Microspores and Microplankton	Megaspores
1	1
2 - 4	2
5 - 9	3 - 4
10 or more	5 or more

* Index species

DISTRIBUTION AND
RELATIVE ABUNDANCE
OF THE MANNVILLE MICROFLORA
IN IMPERIAL WILLINGDON No. 1
WELL (Lsd. 14, Sec. 14, Tp. 55,
R. 15, W. 4th Mer.).

DISTRIBUTION AND
RELATIVE ABUNDANCE
OF THE MANNVILLE MICROFLORA
IN IMPERIAL WILLINGDON No.1
WELL (Lsd.14, Sec.14, Tp.55,
R.15, W. 4th Mer.).

LOWER CRETACEOUS
MANNVILLE GROUP (UPPER)

CLEARWATER FORMATION

GRAND RAPIDS FORMATION

DEVONIAN

JOLI FOU
FORMATION

DEPTH IN FEET

2104 - 2107
2104 - 2104
2098 - 2101
2095 - 2098
2093 - 2095
2075 - 2085
2074 - 2075
2068 - 2065
2045 - 2055
2042.5 - 2045
2040 - 2042.5
2037.5 - 2040
2035 - 2037.5
2032.5 - 2035
2030 - 2032.5
2013 - 2027
1981 - 1991
1971 - 1981
1961 - 1971
1951 - 1961
1941 - 1951
1931 - 1941
1921 - 1931
1911 - 1921
1891 - 1901
1881 - 1891
1866 - 1881
1855 - 1866
1845 - 1855
1836 - 1845
1826 - 1836
1816 - 1826
1801 - 1811
1791 - 1801
1781 - 1791

Species listed on the left include: *Sphagnumsporites antiquasporites*, *S. pilosus*, *Lycopodiumsporites auriculatoides*, *L. canidites*, *L. marginatus*, *L. sp. A*, *Lycopodia sp.*, *Lycopodia cretacea*, *Acantholites valispinosus*, *A. levidensis*, *Osmondacridites wellmanii*, *Rugulatisporites sp.*, *Todisporites minor*, *Appendicisporites hirsutifolius*, *A. cirkmayeri*, *A. jansonii*, *A. eadmonii*, *A. coxsonii*, *A. crumenii*, *A. cf. A. pichetensis*, *A. sp.*, *A. trichanthus var. dissectus*, *A. cf. Anemia trichantha*, *A. unicus*, *A. bifurcatus*, *A. perplexus*, *Citricolpites darogensis*, *C. darogensis*, *C. perfoliatus*, *C. medianspinus*, *C. orbiculatus*, *C. sp. A*, *C. sp. B*, *Chamaetrites almagrensis*, *Schizosporites eocenicus*, *S. phaeus*, *Dicranolites pseudoreticulatus*, *Klukisporites sp.*, *Lygodisporites sp. A*, *L. sp. B*, *Lygodiumsporites sp. A*, *L. sp. B*, *Neosaxitackia ? sp.*, *Galeanites senilis*, *G. cf. G. cecidoides*, *Cyathites australis*, *C. minor*, *Trilobosporites hannonicus*, *T. apiculatus*, *T. canadensis*, *T. hispidulus*, *T. minor*, *Ptilosporites trichopillatus*, *P. veus*, *Concavissimisporites punctatus*, *C. parkini*, *C. varicrucatus*, *C. sp.*, *Deltolepis hallii*, *D. pilosula*, *D. juncea*, *Hymenozonitoides mesozoicus*, *H. pseudovalvatus*, *Coupevisporites complexus*, *Staplinisporites caninus*, *Tauracopites segmentatus*, *T. vedicus*, *T. minor*, *Aegulitridites spinulosus*, *A. variabilis*, *Rousisporites reticulatus*, *R. laevigatus*, *R. triangularis*, *Cochranites variabilis*, *C. reticulatus*, *Janusporites spiniferus*, *Verrucosporites asymmetrus*, *V. rotundus*, *V. sp.*, *Microreticulatisporites uniformis*, *Granulatisporites sp.*, *Loevigatisporites ovatus*, *Diclyotaspites cf. D. speciosus*, *Schizosporites reticulatus*, *S. parvus*, *S. rugulatus*, *Vitelliporites pallidus*, *Cycadapites fragilis*, *C. carpentieri*, *C. formosus*, *C. sp.*, *Bennettiaepollenites minimus*, *B. sp.*, *Perinapollenites elatoides*, *Alisporites cf. A. minoracutus*, *A. thomasi*, *A. rotundus*, *Cedripites crataceus*, *C. canadensis*, *Parvisaccites radiatus*, *Phyllocladites mowatii forma verrucosus*, *P. sp.*, *Podocarpidites cf. P. ellipticus*, *P. multistriatus*, *P. aratus*, *P. minutus*, *P. canadensis*, *P. sp.*, *P. novae*, *Piceapollenites sp.*, *Pityosporites canaliculatus*, *P. alaripollenites*, *Trugopollenites mesozoicus*, *Classopollis classoides*, *Leleates calvatus*, *Exesipollenites tumulus*, *Eucamitoides troedsonii*, *Equisetisporites concinnus*, *E. cf. E. ovatus*, *E. albertensis*, *Palaeopseudium cretaceum*, *P. granulosum*, *Gonyaulax cf. G. jurassica*, *Hystrichosphaeridium tubiferum*, *H. albertensis*, *H. irregularis*, *Baltisphaeridium longispinosum*, *B. cf. B. neptuni*, *B. sp.*, *B. multipinosum*, *Verrucosporites verrucosus*, *V. irregularis forma subhexahedron*, *Pseudocerasium peltiferum*, *P. gochii*, *Canningia calliveri*, *Odonochlina operculata*, *Triletes penimilis*, *T. sp. A*, *T. sp. B*, *Monisporites reticulatus*, *Verrucosporites cf. V. campopunctatus*, *Eragmosporites reticulatus*, *E. sparsus ?*, *E. glaberrimus*, *E. sp.*, *Macropollenites apiculatus*, *M. obolus*, *Thamnia phyllis*, *Minelapollenites macroreticulatus*, *M. marginatus*, *M. venustus*, *Diktaosporites helios*, *D. triangularis*, *Ascelites rugosus*, *A. reticulatus*, *A. incipiens*, *A. nudus*, *A. disciformis*, *D. cf. D. sp.*, *Caytonia seed with integument*, *Nucleus of Caytonia seed ?*

TOTAL NUMBER OF SPECIES PER SAMPLE

1 7 13 29 20 13 0 14 13 8 16 12 9 16 4 10 15 3 7 12 23 20 25 13 10 5 12 14 8 20 32 5 3 14 9

LEGEND

	Microspores and Microplankton	Megaspores
I Single	1	1
O Rare	2 - 4	2
● Common	5 - 9	3 - 4
● Abundant	10 or more	5 or more

* Index species



B29820